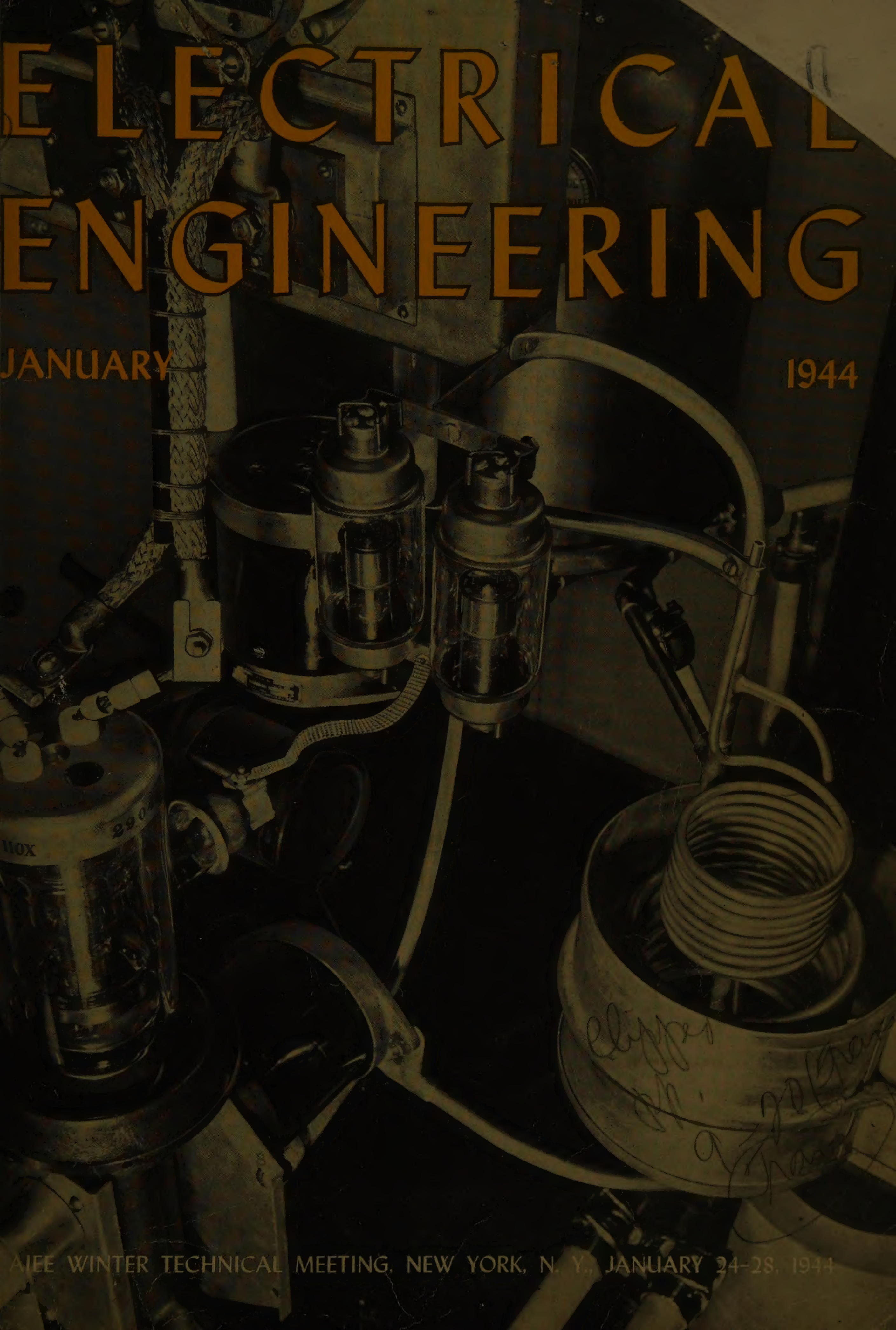
ELECTRICAL ENGINEERING

JANUARY 1944



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The Cover: Interior view of five-megacycle induction electronic heating unit capable of continuously delivering 25-kw output. Photo courtesy Federal Telephone and Radio Corporation

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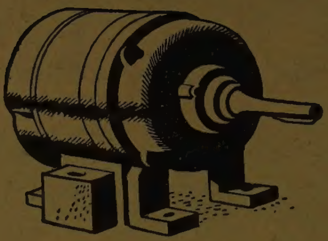

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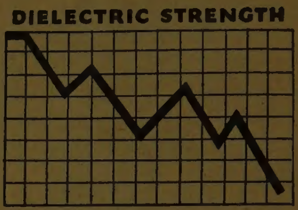

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ELECTRICAL INSULATIO

Electrical Sinews for the Big Inch Pipe Lines

MERRITT A. HYDE
ASSOCIATE AIEE

The 24-inch pipe line, the Big Inch, will transport 300,000 barrels of crude petroleum 1,400 miles daily from the heart of Texas oil fields to the Eastern Seaboard. The new 20-inch refined-products line is 150 miles longer and has a capacity of 235,000 barrels per day of refined products. Power supply, substations, motors, and controls of the operating equipment, as well as high lights of the construction problems are discussed in this article by an outstanding authority on electrical problems associated with oil pipe lines.

THE NEW 24-inch oil-pipe-line project, the Big Inch, the greatest in the realm of petroleum transportation, as been carried to rapid completion under wartime contions of engineering and construction, as a vital factor the war effort. In fact, "Big Inch" has become nother American byword of construction accomplishment.

From the viewpoint of power application, Big Inch is a 400-mile underground conduit, 24 inches in diameter r 1,264 miles of its length, from Longview, Texas, to hoenixville, Pa., where it divides into two 20-inch lines, ne branch to the Philadelphia area, totalling some 40 pe miles, the other about 90 miles to the New York rea.

The route encounters all varieties of terrain ranging om the Mississippi bottoms to the ridges of the Allehenies. Between an elevation of 313 feet at Longview nd seaboard at its eastern rmini, its highest point is the ,920-foot Laurel Hill crossg, in Pennsylvania.

When operating at its ultiate capacity, the line will arry a continuous 1,400-mile olumn of oil from Longview Linden, N. J., more than ,000,000 barrels of it, weighg 600,000 tons, moved at a peed of about $4^1/_4$ miles per our. To accomplish this reuires a total propelling force quivalent to about 2,450 tons. his force and rate of motion epresent the continuous exenditure of nearly 100,000 horsepower—by that measure ne of man's greatest pumping jobs.

This task is performed by electrically driven centrifugal umps. The aggregate installed electric-motor capacity, pplied to main-line pumping, is approximately 125,000 orsepower. This capacity is in 83 units of 1,500 horseower each, in essentially 28 stations at intervals averaging bout 50 miles, three units per station. Additional spare nd auxiliary units bring the total installed horsepower to bout 130,000.

In these days of big numbers, installation of 130,000 orsepower of power equipment in a pumping plant might e announced with some eyebrow lifting, but not with uch breath-taking effect. The real interest in this projct is in its nature, not its size. It is one thing to build and un a 130,000 horsepower pumping plant on some paricular site. It is quite another matter to design, construct, nd operate the equivalent capacity in 28 stations interependent in the performance of a single operation yet xtended over a 1,400-mile strip of ground.

The whole character of pipe-line operation stems from this subdivision into stations separated geographically but joined physically. The use of a number of stations along the line instead of one station at the origin of the line is dictated by the necessity of limiting the station delivery pressure to a value that develops a piping stress within the allowable limit. If the pumping capacity on the 24-inch crude line could be combined into one station at Longview, delivering 300,000 barrels per day through the 1,264 miles of 24-inch line to Phoenixville, with a pressure drop per mile of 12 pounds per square inch, and against a static head of 50 pounds per square inch due to difference in station elevations, then Longview station would have to operate with a discharge pressure of 15,250 pounds per square inch. Of course, this is an impractical condition from the standpoint of pipe design alone. But by dividing this pumping job among 24 stations along this portion of the line, the average net differential pressure input at each station becomes about 635 pounds per square inch. Allowing for a suction pressure at each station of 50 pounds per square inch, the station discharge pressure would be 685 pounds per square inch. In actual operation, capacity flow is somewhat higher than the 300,000 barrels per day nominal rating of the line, and the net differential pressure at each station is in the neighborhood of 675 pounds per square inch. With a suction pressure of 50 pounds per square inch, this means a maximum line pressure at the station discharge of 725 pounds per square inch, a practical value from the standpoint of pipe design.

The average spacing for 24 stations over 1,264 miles of line is 52.5 miles. Actually distances between stations vary from 31 to 78 miles, the spacing being closer for uphill and wider for downhill terrain. In each case the spacing is such that the pressure increment developed by the station is equaled by the static-head difference between that station and the succeeding station, plus the friction drop at capacity flow for the length of piping between the two stations. Figure 1 is a diagram illustrating this point.

This profile for a section of pipe line does not apply to the Big Inch right of way, but it will serve as a basis of discussion. The line throughput is taken as 300,000 barrels per day of oil with specific gravity 0.85, with a friction drop per mile of 12.0 pounds per square inch or 32.6 feet head. Minimum allowable station suction pressure is taken as 50 pounds per square inch, or 135 feet head. The net pressure increment at each station is taken as 635 pounds per square inch or 1,725 feet head. If one proceeds from station *A*, it is evident that the site of station *B* is determined by the location at which the suction head

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ssential substance of an address presented before the power group of the New ork Section of AIEE, in New York, N. Y., October 14, 1943.

errritt A. Hyde is petroleum and chemical engineer, industry engineering departent, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

he author acknowledges the assistance of Oscar Wolfe, chief engineer, and A. S. unneke and J. L. Gates, electrical engineers of War Emergency Pipe Lines, Inc., n the preparation of this article.

reaches the established minimum value of 135 feet. This spot is 33.8 miles from station *A*, the trend of the terrain being uphill. If one proceeds from station *B* in the same manner, but with generally downhill terrain, the suction head limit for station *C* is reached at a distance of 58.7 miles—substantially greater spacing than for the uphill terrain between stations *A* and *B*.

For a given capacity, fluid condition, and pipe condition, the friction pressure drop per mile is fixed. For interchangeability of pumping equipment it is highly desirable to maintain essentially uniform station incremental pressures throughout the line. Under these conditions the station sites are determined quite rigidly by the hydraulics of the line, and their selection is not subject to appreciable flexibility in the interest of convenience in other respects. This fact is important in regard to power service; it means that station locations cannot be chosen to facilitate power service, rather, power-service facilities must be extended to station sites as determined by pipe-line hydraulics.

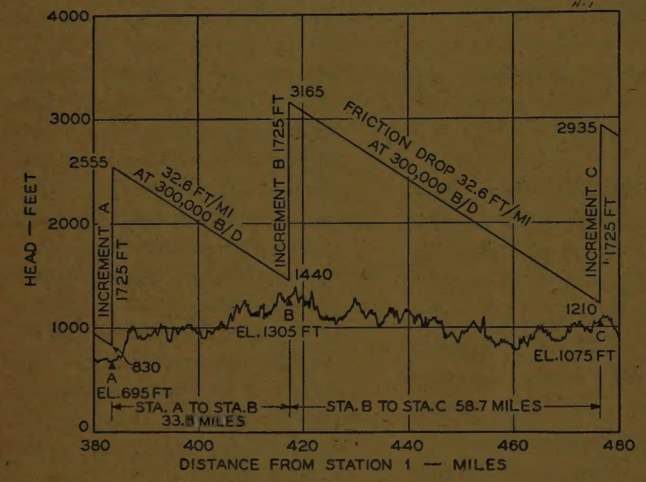

Figure 1. Typical pipe-line profile and pressure-gradient chart

Station locations are determined by the minimum allowable incoming pressure

In the course of 1,400 miles of right of way, it is to be expected that a variety of power-service conditions would be encountered. Power is delivered to the station sites by 17 different utility companies, involving new line constructions varying from a few miles up to, in one instance, 120 miles of line for serving three stations. Service voltages range from 22 to 110 kv. In all stations the bus voltage is 2,300, stepped down from service voltage through one three-phase transformer rated, in general, 3,750 kva with provision for future addition of air-blast equipment, which will permit realization of 5,000 kva capacity. The transformer primary windings are provided with undervoltage taps for adjustment to deliver the required station bus voltage under conditions of reduced line voltage. The transformer-substation installation includes primary disconnect switch, lightning arresters, and fuses.

Figure 2 is a view of the power-service facilities at one of the Big Inch stations receiving power over a 110-kv transmission line. Figure 3 is a diagram showing more clearly the arrangement of power-service facilities and is typical as well for the station switchgear, motors, and pumps. From the outdoor substation, power enters the

Figure 2. View of typical pumping station and 110-kv substation

The 3,750-kva three-phase transformer delivers power at 2,300 volts to the station bus and the auxiliary power and lighting transformers (center)

pumping-station switchgear at 2,300 volts. In this switchgear it passes through a main breaker and thence to a bus from which it is tapped to each motor through suitable starting equipment.

This starting equipment is of the full-voltage type wherever the power-service facilities are adequate to handle the across-line starting current of the motors, which is about 1,500 amperes or five times full-load current. In 14 of the 28 stations, reduced voltage starting was deemed necessary, and the equipment in these stations is of the autotransformer type providing closed-circuit starting transition. If a tap voltage of 65 per cent is used, the starting demand from the 2,300-volt bus becomes about 740 amperes. Higher starting taps are provided—and generally used—to insure delivery, even with substantial drop in the primary voltage, of sufficient voltage to the motor to enable it to develop the torque required to accelerate the pump.

The pump-accelerating torque requirement is minimized by the practice of starting with suction valve open and discharge valve closed. The static torque is less than 20 per cent, and the load torque increases as the square of the speed, from substantially zero after breakaway to about 45 per cent at full speed with the discharge valve closed. After the unit reaches full speed, the discharge valve is opened, and normal running load ensues. These motors, having pull-out torque about twice full-load torque, can carry the pump at full load through a substantial

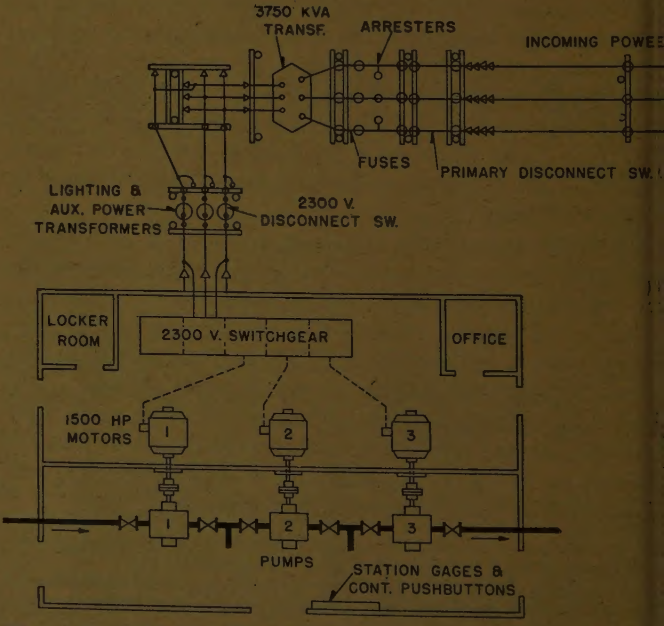

Figure 3. Diagram showing electric-power service and mai circuits in 24-inch-line pumping station

voltage dip—down to a voltage approximately 70 per cent of normal. Within that range the starting of one unit does not affect appreciably the operation of other units which may be running. This means that for a particular pumping station the choice between across-line starting and reduced-voltage starting is determined by the ability of the power system to handle the starting demand with acceptable voltage service to other power users on the system.

A typical installation of full-voltage starting switchgear is shown in Figure 4. The two left-hand units house the potential and operating transformers and the main circuit breaker, with metering and relaying for the incoming line. The remaining three units each control one 1,500-horsepower pump motor.

Each motor control unit provides time-delay undervoltage protection, and also instantaneous short-circuit protection and locked-rotor protection. Running load protection is provided by a thermal relay which follows closely the heating characteristic of the motor.

The switchgear is of the metal-clad vertical-lift breaker type, with the well-known features of safety, interchangeability, and complete factory assembly—outstanding advantages for pipe-line station service. All circuit breakers are 7.5 kv, 100,000 kva interrupting rating, 600 amperes for the motor units and 1,200 amperes for the incoming line. A spare 1,200-ampere breaker is interchangeable in all the units.

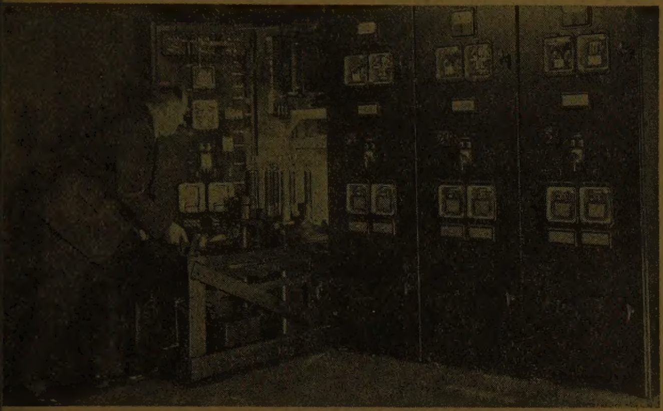

Figure 4. Metal-clad switchgear controlling 2,300-volt incoming line and three 1,500-horsepower pump motors using full-voltage starting

The circuit breakers, mechanically interchangeable, are easily removed and replaced

Figure 5 shows reduced-voltage switchgear and three 1,500-horsepower 1,780-rpm motors driving main-line pumps, each through a stuffing box in the fire wall separating the pump room from the motor room.

These motors are of the squirrel cage induction type, rated 40 degrees centigrade rise open. Their ventilation is by air intake at both end brackets, with discharge through an opening in the top of the motor frame. Each motor is installed with a so-called "top hat" through which the warm discharge air is drawn into a duct and expelled through the roof by a small motor driven blower. Provision is also made for circulation of this air as a means of heating the station in cold weather.

The motor room is completely separated from the pump room by a fire wall, with no communicating doorways, it being necessary to go outside the building when passing from the one room to the other. With this arrangement the motor room is considered nonhazardous, and the equipment and installation in this room are of conventional type for nonhazardous location.

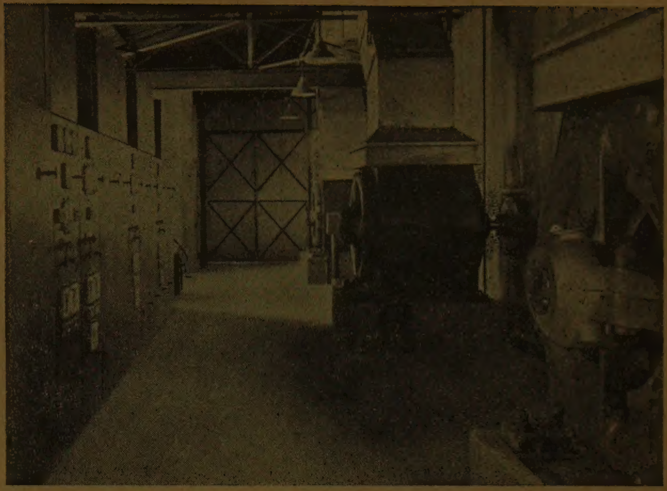

Figure 5. General view of motor and control room showing reduced-voltage starting switchgear and three 1,500-horsepower pump motors

Shaft seal in wall separates motor room from pump room

The pump room, however, is considered hazardous. Figure 6 shows the pump room with the three units, arranged in series, the incoming flow entering the suction valve of unit 1 in the foreground. The pumps are surprisingly compact, being single stage, 16 by 12, rated 8,750 gallons per minute, 648 feet head, at 1,780 rpm. The discharge valve of unit 1 can be seen just beyond the pump, followed by unit 2 with its valves, and in turn by unit 3 and valves.

From the standpoint of electrical devices and wiring, the pump room as mentioned previously is a hazardous atmosphere location, made so by normal drainage from the pump glands, by pump-casing venting operations, and by any abnormal leakage from pump glands, valves, piping, and fittings. The push buttons in the pump room for starting and stopping of the units are of the explosion-proof type. Likewise the pressure-protective relays, of which more will be said later.

The suction and discharge valves associated with each pump are manually operated, the 16-inch suction valve requiring 156 turns for its complete travel and the 12-inch

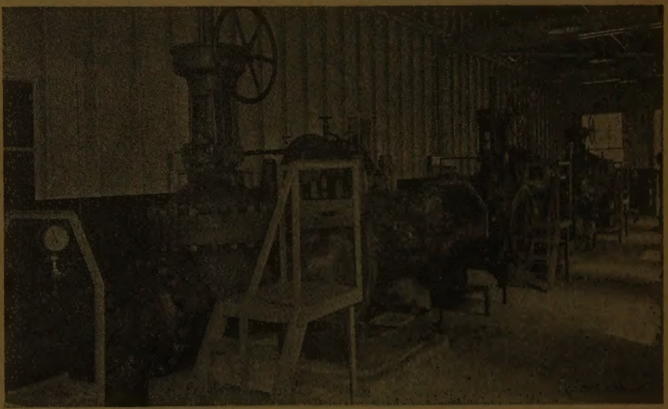

Figure 6. View from suction end of pump room in a Big Inch station, showing the three pumps connected in series

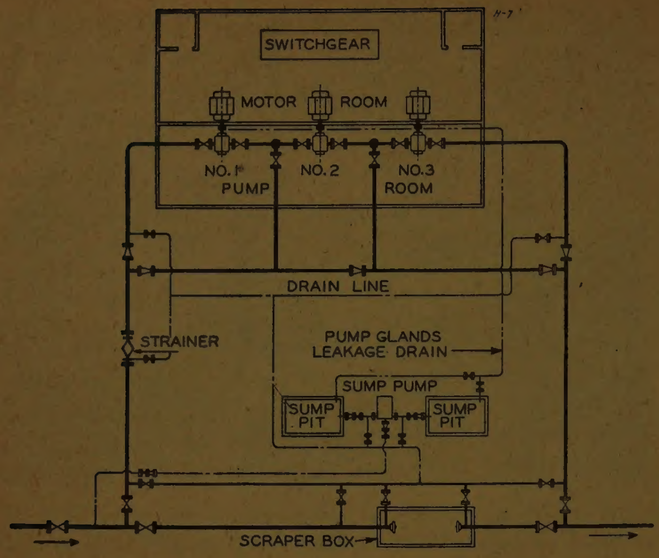

Figure 7. Piping diagram for a typical Big Inch station

discharge valve 118 turns. Rapid operation of these valves taxes the physical capacity of one man, and it seems probable that they will be converted to motor operation when the availability of such apparatus becomes less critical.

The co-ordination and control of the many component parts of a typical station are an important problem. The main 24-inch line enters and leaves the station site as shown at the bottom of Figure 7, where a scraper box, interrupting the line, provides for the handling of incoming and outgoing scrapers, employed to clean the line. By suitable valve positioning, the stream is detoured through the station, where it receives the pressure increment developed by the pumps and resumes its travel along the line. Also in this diagram can be seen the suction and discharge valves of each unit and the check valves which permit bypassing the individual units or the station.

The starting and normal stopping of stations and of units within stations are by direction of the dispatcher, who is located in the headquarters office at Cincinnati. Continuous intercommunication between the dispatching office and all stations is provided by teletype with telephone available as a supplementary means.

In starting the line from complete shutdown, when all stations are in readiness, the dispatcher instructs station 1 at Longview to start one unit, and the other stations each to start one unit when the line pressure at that station begins to rise in response to the operation of the upstream stations. The operator has at a central location in the pump room, two gauges reading "station suction pressure" and "station discharge pressure" and mounted with them the three push-button stations controlling the individual units. Without having to lift his glance from the gauge he can push a start button, and within ten seconds the pump is up to speed ready for its discharge valve to be opened.

In succession the stations start unit 1 and, when all are operating with one unit, the dispatcher may call for starting unit 2 beginning at Longview and progressing throughout the line in the same way. Finally, to operate at full capacity, the dispatcher may instruct all stations to start unit 3 following the same procedure. Should conditions dictate intermediate throughputs, the dispatcher can accomplish this by holding selected units, or stations, out of service; however, in so doing he must distribute the operating capacity along the line so that suction and discharge pressures at all stations fall within prescribed limits. This requires very carefully worked-out schedules to prevent the occurrence of prohibitively low suction pressures at some stations and excessive discharge pressures at others, or to avoid undue throttling at some stations (throttling is an inefficient means of dissipating excess pressure within the station). Thus, it is apparent that flexibility in normal starting and stopping is an important contribution by electrical control to the operation of the line.

Of still more importance is the adaptability of electrical control to protective shutdown functions. As already indicated, it is necessary at all times to hold the operating pressures on the line and in the stations between definite limits of low suction and high discharge pressures.

Low suction pressure permits vaporization of the liquid with possible damage to the pump. To guard against this, a relay is provided, having its pressure element connected to the station suction. Its contacts sound an alarm at about 35 pounds per square inch, thus warning the operator, who may be able to correct conditions by throttling adjustment. Failing this, a second low-pressure relay functions at about 20 pounds per square inch to cause shutdown. Both of these devices are capable of higher or lower settings.

By suitable electrical control, the low-suction-pressure shutdown relay is arranged to stop the units in timed sequence, beginning with the downstream unit, with an interval of about five seconds between shutdowns. If upon shutting down a unit, the station suction pressure rises above the reset point of the protective relay, the remaining units are allowed to continue in operation. However, if the suction pressure persists below the protective-relay setting, the remaining units are stopped automatically in sequence at five second intervals.

Protection against excessively high line pressures at the station discharge is provided by a pressure-actuated relay, similar to the low-suction-pressure protective relay and set to function when pressure exceeds about 900 pounds

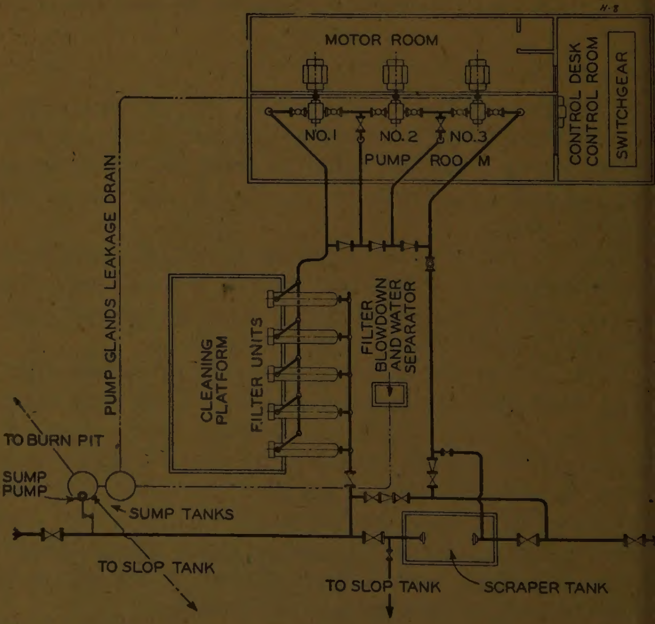

Figure 8. Piping diagram of typical station of the 20-inch refined-products line

er square inch. An additional pressure relay between nit 2 and unit 3 will allow a pressure at this point not nore than 250 pounds per square inch above normal disharge pressure of unit 2. These high-pressure protective elays also will shut down successive units in timed seuence.

In event of a protective shutdown due to abnormal ressure, the operator may have difficulty in identifying he particular relay that functioned. To provide this nformation quickly, a visible annunciator is being designed for operation in conjunction with the pressure proective devices. This annunciator will be mounted in the ump room, in an explosion-proof housing, adjoining the tation pressure gauges and the push buttons which conrol the three pump units.

With these protective devices, the station can operate at a wide range of pressure conditions within the limits for which the devices are set, and yet have the benefit of protective shutdown when some abnormality results in pressures exceeding the predetermined limits.

These vital protective functions are made possible in simple reliable form through the medium of electrical control. Thus, electricity provides not merely the sinews that make Big Inch a moving thing, but also the nerves that direct and protect it in the performance of its mighty task.

And now Big Inch has a rival, the new 20-inch refined-products line under completion from Beaumont, Tex., to the Philadelphia and New York areas.

Called "little Big Inch" because it's a trifle smaller in the waist, it is 150 miles longer, and it really packs a bigger wallop than Big Inch, for its 235,000 barrels per day capacity of refined products will represent the equivaent of some 370,000 barrels per day of crude oil.

Little Big Inch, drawing products from ten refineries in the Baytown and Beaumont areas, runs 350 miles to Little Rock, Ark., where it joins the right of way of the 24-inch line and follows it from there on to the East. Beginning at Little Rock the 20-inch-line stations are at the same sites as the stations on the 24-inch line. Thus substantial savings are effected in costs of right of way, station sites, power procurement, energy, operating labor, and operating maintenance.

Station layout on the 20-inch line, as indicated by Figure 8, will be quite similar to that of the 24-inch line. However, the handling of refined products entails the addition of filter units.

Power-service facilities are entirely similar to those of the 24-inch line. Transformers of 3,750-kva rating are being installed, the two transformers at each site to operate in general from a common primary feeder with independent secondary circuits to the respective pump houses.

Ultimately it is likely that a 2,300-volt bus tie will be installed with a normally open switch. Upon failure of either of the transformers, closure of this bus tie would permit both stations to be loaded from one transformer which, cooled by air blast, would permit operation of selected units in both stations.

Main switchgear for the 20-inch-line stations is interchangeable with that of the 24-inch line. An additional matching unit houses the station sequence control to be described later.

The three pump units are driven by 1,250-horsepower motors at 3,575 rpm, similar to the 24-inch-line motors in ventilation arrangement. A principal feature of the motor construction, is the provision of flood lubrication by a shaft-driven oil pump. Like the 24-inch-line motors, these units are co-ordinated as to mounting dimensions, so that all main pump motors on the 20-inch line are mechanically interchangeable, regardless of manufacture.

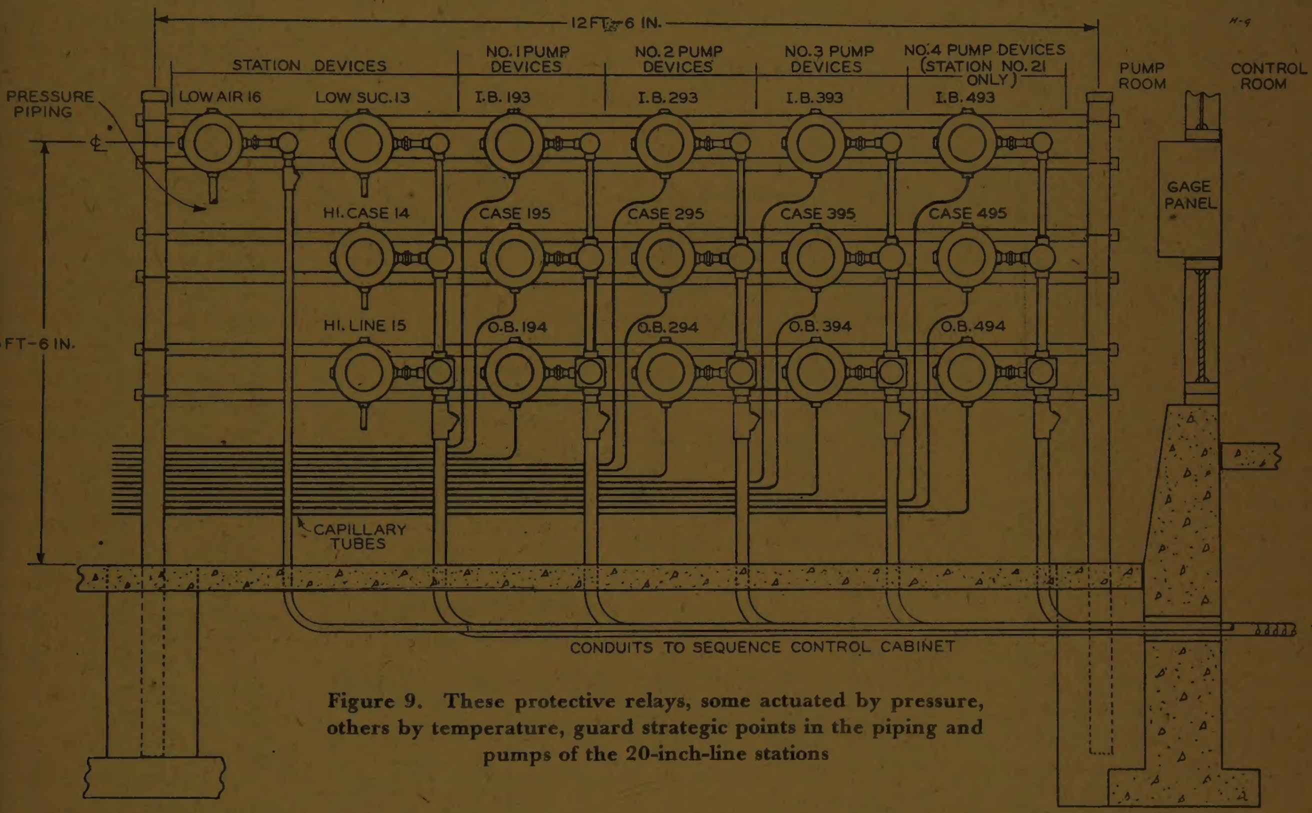

Figure 9. These protective relays, some actuated by pressure, others by temperature, guard strategic points in the piping and pumps of the 20-inch-line stations

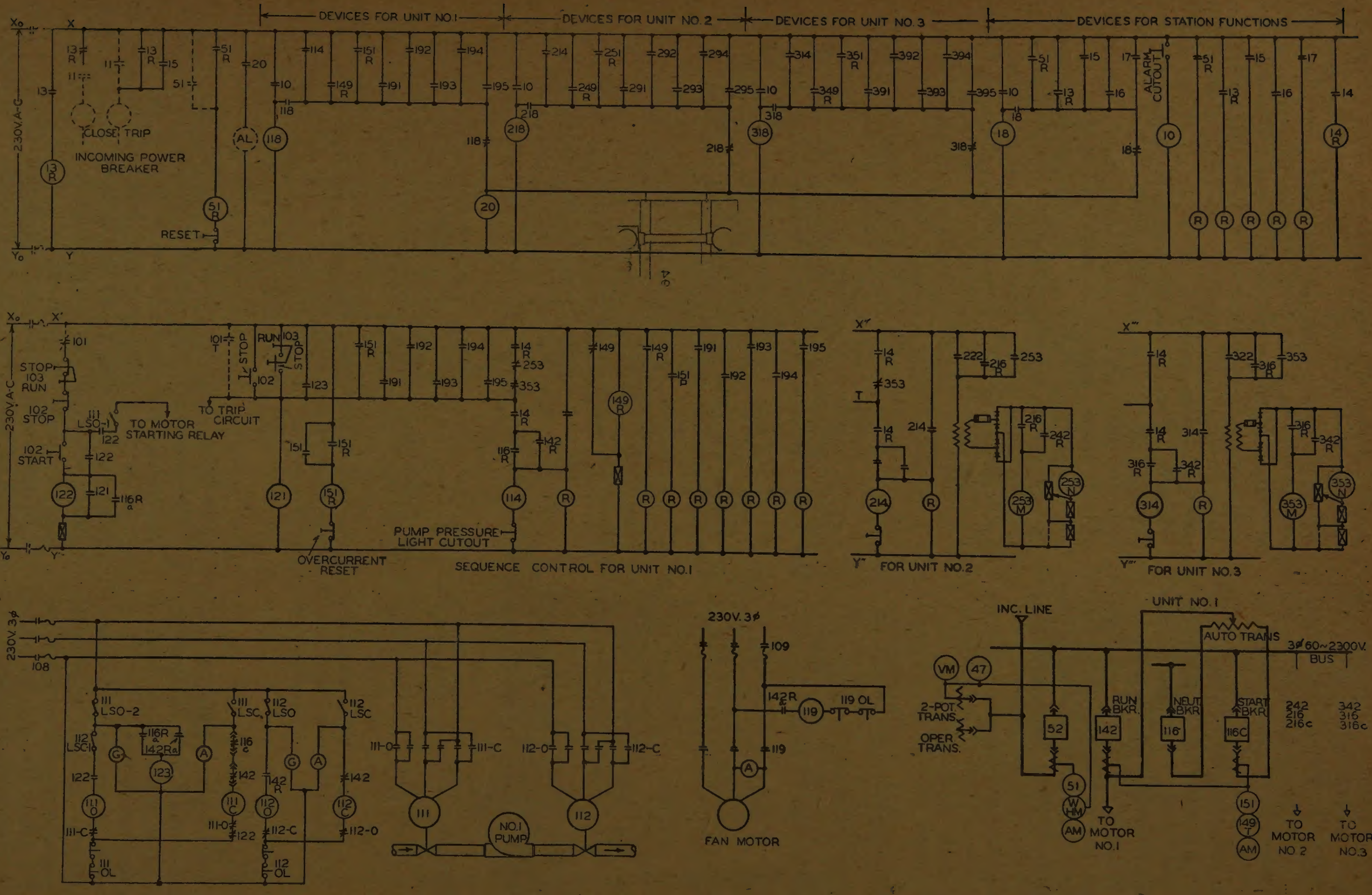

Figure 10. Schematic diagram of station sequence control for 20-inch products line, three-station unit, using reduced-voltage starting

Except for those devices shown in broken lines, the main switchgear is not included in this diagram Symbol identification

(A)—Amber indicating light on control desk
(G)—Green indicating light on control desk
(R)—Red indicating light on control desk
AL—Audible alarm
10—Alarm cutout relay
11—Control switch for incoming line breaker
13—Low-station-suction-pressure protective relay
13R—Auxiliary relay to 13 (shown with pressure on suction line)
14—High-pump-pressure protective relay
14R—Auxiliary relay to 14
15—High-station-discharge-pressure protective relay
16—Low-air-pressure protective relay
17—High-sump-level protective relay
18—Auxiliary alarm relay
20—Alarm relay
47—Reverse phase relay
51—Overcurrent relay of incoming line breaker
51R—Auxiliary relay to 51
51 Reset—Reset push button for incoming-line overcurrent auxiliary relay
52—Incoming line circuit breaker
101 (201, 301)—Control switch for motor, trip-permissive
102 (202, 302)—Motor start-stop push button on control desk
103 (203, 303)—Motor stop-run push button, at pumps
108 (208, 308)—Valve motor breaker
109 (209, 309)—Fan motor breaker
111 (211, 311)—Suction-valve motor
111-C (211-C, 311-C)—Suction-valve contactor—close
111-O (211-O, 311-O)—Suction-valve contactor—open
*111-LSC (211-LSC, 311-LSC)—**Suction-valve limit switch—closed limit*
*111-LSO (211-LSO, 311-LSO)—**Suction-valve limit switch—open limit*
112 (212, 312)—Discharge-valve motor
112-C (212-C, 312-C)—Discharge-valve contactor—close
112-O (212-O, 312-O)—Discharge-valve contactor—open
*112-LSC (212-LSC, 312-LSC)—** Discharge-valve limit switch—closed limit*
*112-LSO (212-LSO, 312-LSO)—** Discharge-valve limit switch—open limit*
114 (214, 314)—Auxiliary relay to 14
116 (216, 316)—Magnetizing breaker of motor switchgear
116C (216C, 316C)—Starting breaker of motor switchgear
116R (216R, 316R)—Auxiliary position relay for magnetizing breaker of motor switchgear
118 (218, 318)—Auxiliary alarm relay
119 (219, 319)—Fan-motor control contactor
121 (221, 321)—Lockout relay
122 (222, 322)—Sequence relay
123 (223, 323)—Sequence relay
142 (242, 342)—Running breaker of motor switchgear
142R (242R, 342R)—Auxiliary position relay, for running breaker
149 (249, 349)—Motor winding-temperature. Alarm relay
149R (249R, 349R)—Auxiliary relay to 149 (249, 349)
149T (249T, 349T)—Motor thermal overload relay
151 (251, 351)—Overcurrent relay of motor switchgear
151R (251R, 351R)—Auxiliary relay to 151 (251, 351)
151 Reset (251 Reset, 351 Reset)—Reset push button for motor overcurrent auxiliary relay
(253, 353)—Sequence timing relays for high-pump-pressure tripping
191 (291, 391)—Motor outboard bearing temperature protective relay
192 (292, 392)—Motor inboard bearing temperature protective relay
193 (293, 393)—Pump inboard bearing temperature protective relay
194 (294, 394)—Pump outboard bearing temperature protective relay
195 (295, 395)—Pump-casing temperature protective relay
VM—Voltmeter
AM—Ammeter
WHM—Watt-hour meter

***Valve-limit-switch positions are shown for both valves in closed position. Limit switches LSC change position at closed end of travel and limit switches LSO change position at open end of travel*

The pumps are single stage, 14 by 12, operating three units in series to handle 235,000 barrels per day of gasoline developing a total pressure of approximately 750 pounds per square inch.

The principal differences in the 24-inch and 20-inch tation designs lie in the system of station control, occaioned largely by the greater precision justified in productsine operation to minimize contamination between producits. The suction and discharge valves of each pump are motor operated, and the complete pumping unit, with valves, is controlled by a single "start–stop" pushbutton.

Protective relays actuated by pressure and temperature are used somewhat more extensively in the 20-inchine stations. In addition to low-station-suction-pressure and high-station-discharge-pressure protection, there is a pressure relay connected immediately upstream of the tation throttling-control valve. If excessive pressure occurs at this point, this relay stops whichever unit is operating as the final unit in the station, and, if pressure conditions are not restored to normal within some three seconds, then it proceeds to stop the next unit in time sequence, and finally, if abnormal pressure still persists, it stops the remaining unit.

Temperature-actuated reays are employed in all pump casings, pump bearngs, and motor bearings, and on the motor windings.

Figure 9 shows the method of installing the pressure and temperature protective relays associated with equipment in the pump room. It will be noted that each relay is in an explosionproof housing.

In general each protective relay actuates circuits to perform three functions:

1. Sound an alarm.

2. Energize an indicating light to identify the protective device that operated.

3. Stop the unit, or the station. Certain relays provide alarm and ight signal only, leaving corrective action to the operator. This is rue in the case of high temperature in motor windings, high level n the sump to which gland leakage is drained, and low air supply to the pressure controllers.

The scheme of control for performing these functions s shown in Figure 10. Because of the unusual interest n this control, this drawing, of more than usual detail, is ncluded.

A feature in line with recent practice on other products pipe lines is the provision for throttling at the station discharge under automatic control by pneumatic controllers. This system is designed to throttle the station discharge when necessary to maintain the station suction pressure above a predetermined low limit, say 30 pounds per square nch, or to maintain the line pressure beyond the station discharge below a predetermined pressure, say 800 pounds per square inch. This system is also useful in bringing pumping units onto the line, as it provides regulation of he maximum station discharge pressure to the discharge control instrument setting. When a unit is placed into ervice, this setting can be adjusted readily to limit the effective station increment pressure initially to substantially the value that existed before starting the unit. Then the station increment can be raised gradually by reduction in throttling, thus making the additional pump pressure effective on the line with minimum hydraulic disturbance. This procedure avoids shutdowns during starting operations, that otherwise might result from pressures exceeding the allowable range with consequent functioning of the protective relays.

Nerve center for all these control operations and protective functions is the station control desk and the associated sequence-control cabinet. Figure 11 shows how the several circuits from the pump and motor rooms—from the lockout push buttons, the motor operated valves, and the protective pressure and thermal relays—all converge in the station sequence-control cabinet. In it are assembled the necessary relays to translate the incoming impulses into proper action by the switchgear, valves, auxiliary blower controls and, when necessary, the station alarm. At the same time the station sequence-control equipment sets up proper circuits to the control desk to keep the operator informed by indicating lights as to the functioning of the various apparatus.

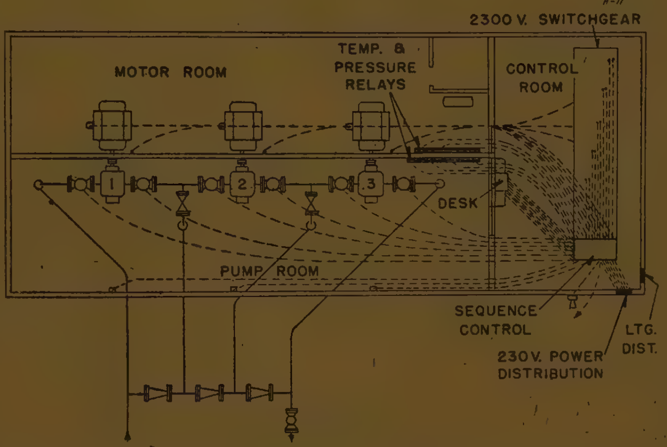

Figure 11. Typical conduit layout for power and control wiring in a 20-inch-line station

From the station control desk all major operations of station control are performed. Installed in the partition between the control room and the pump room, it is surrounded by a large glassed area permitting view of the pump room and motor room. To facilitate this view, the gauge-panel section is designed low, so that the operator can look over the top of the unit.

The gauge-panel section consists of a compartment having rear doors opening into the pump room to permit servicing the hydraulic instruments. The front is a panel surface facing the control room, on which the instruments are mounted with gaskets. This gauge-panel compartment is gasketed into the partition to prevent seepage of hazardous vapors into the control room, and, as an additional precaution, the control room is kept under a small pressure of clean air drawn from the outside of the building.

Instrumentation consists of:

Suction-pressure controller and recorder.

Suction-pressure indicating gauge.

Pressure gauge for air to pneumatic controllers.

Air-pressure-regulator adjusting valve.

Clock.

Discharge-pressure indicating gauge.

Discharge-pressure controller and recorder.

A horizontal surface below and at each end of the gauge panel provides writing space and accommodates the station log sheet.

The electrical section of the control desk is a separate unit isolated from the gauge-panel compartment, located entirely within the control room, mounting push buttons and indicating lights for the master station control. The desk-top surface is a sheet of transparent plastic, backed with a schematic design of the main piping within the station, and showing the main-line valves, pumps, and driving motors.

From a single "start–stop" push button, the operator controls each pump unit, the valve motor control and pump motor control automatically functioning in proper sequence for starting up and shutting down. Indicating lights in the desk-top diagram show the valve positions, and small illuminated arrows show the actual course of the stream through the station piping in accordance with the particular units operating.

If trouble should develop at any of the protective-device locations, a small red indicating lamp appears at the appropriate spot in the station diagram, and the operator is given an audible signal. In addition, certain of the protective devices automatically shut down the particular unit involved, or the station. In each case, the audible signal continues until it is silenced by an alarm cutout button, and the particular indicating light burns to tell the operator exactly where the trouble is until it is extinguished by manual reset at the protective-device location, when the trouble is cleared.

This desk and the associated system of control greatly simplify the duties of the station attendant, increase the reliability of station operation, and facilitate location of the trouble spot in case of abnormal shutdown. Checking continuously the pulse and the temperature of the station equipment, the desk has been called appropriately, "pipe line nurse."

The building of the world's two largest pipe lines in a little over two years is a tremendous task. It is tremendous in tonnage of materials, in distances, and terrain, and in the co-ordination of work and supplies. To have accomplished these things in the time involved is indeed a tribute to the oil industry, its engineers, and all associates. The electrical industry is proud that within the time prescribed it could co-operate and co-ordinate its activity with the broad requirement of the oil industry, not only to supply the prime power, but also to assist in the perfection of control which has contributed and will contribute so greatly to the performance of the job.

Engineering in Wartime

L. A. UMANSKY
MEMBER AIEE

Our engineers and laboratory workers are pointing the way toward the salvation, conservation, and replacement of critical materials needed for war production, says this industrial engineer. Through their developments the quality of American industry's products has not suffered, and many lessons that will be useful in peacetime have been learned.

IN ITS BROAD and direct sense "engineering" means making the most skillful and efficient use of available materials and of human effort. War has not changed this fundamental conception. On the contrary, it has accentuated its importance.

As compared with other nations, the United States has been rather lavish in its past use of natural resources—primarily because there were so many and so much of them, and because they were considered "cheap." It has come to us as an unpleasant surprise that in this total war even *our* resources are being stretched to the limit, or even beyond this limit. Furthermore, the fortunes of war have deprived us, either fully or in part, of many other indispensable materials around which a number of our industries have been built.

It was a peacetime saying that an engineer should do for a dollar what would take others two dollars, and yet get the same, or better, results. Now, in the economy of war and scarcity, the dollar cannot always be considered as a true yardstick of accomplishment. To save a pound of copper may be more important than to save a pound of silver or gold. In short, our engineers are charged, first of all, with the task of stretching our supplies—of making one pound of copper, rubber, or tin do the work of two or more pounds.

There are three ways in which critical materials can be saved:

1. We can substitute for them other, more readily available materials.
2. We can work available materials harder.
3. We can use available materials more skillfully.

Obviously, we can combine all three methods.

How successful have been the engineers in fulfilling this task? True, the time is not yet ripe to answer this

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Essential substance of an address presented at the Northeastern New York War Production Conference in Schenectady, N. Y., April 15, 1943.

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question in full. But we can plainly see the trends and the partial accomplishments. Being an electrical engineer, naturally I will illustrate this point by cases taken from the electrical field, even though other industries have done equally as well, I am sure.

The list of critical materials requiring alternates is long indeed. Aluminum, to cite a random example, stands high on this list. Aircraft obviously has a first call on this metal. Until the aluminum expansion program is completed, sometime in 1943, the electrical industry will not have all the aluminum it would require normally. An alternate for the cast aluminum in squirrel-cage rotors could be copper, of course, but copper is as scarce as, or scarcer than, aluminum, and making rotor copper windings would require far more labor, which is becoming the scarcest item of all. Reclaimed aluminum, not suitable for airplane construction, but with all good electrical properties, therefore is being widely used.

In many types of equipment, aluminum was employed formerly to get lightweight moving parts or to obtain an easily manufactured design, such as die casting. Many of these moving parts are now made of steel—and by thinking and working harder, the engineers and draftsmen have succeeded in most cases to change the design so as to maintain substantially the same weight. Zinc die castings also are used as substitutes. By these and similar steps, one electrical manufacturer alone has reduced his annual consumption of aluminum by some 8,000,000 pounds.

To cite another example, the shortage of tin has hurt production primarily in the manufacture of babbitt for bearings. Our prewar standard called for a composition containing 83 per cent tin. Conventional lead-base babbitt was not nearly as good. After intensive research work, a high-grade lead-base alloy was found which answered the purpose. In this manner, one manufacturer alone, will save over 200,000 pounds of tin per year.

A few others of the thousand and one critical materials for which substitutes had to be found are chromium, nickel, and nonmetals like tung oil, shellac, mica. Thanks to engineers and laboratory workers, this work has been done; the quality of American industry's products has not suffered, and many lessons that will be useful in peacetime have been learned.

But by far the most important material, without which the electrical industry could not exist at all, is copper. And copper *is* scarce. In a "normal" prewar year, an average of 2,000,000 tons of copper was used in the United States. About 40 per cent of this amount has been used for current-carrying purposes, that is, in electrical machinery, transmission and distribution lines, in radio, telephones, and telegraph. The domestic production of copper has not been increased materially. Imports from South America are subject to shipping difficulties. Hence, our supply of available copper definitely is limited. At the same time, the amount of electrical apparatus manufactured has been more than doubled and the copper requirements for other war matériel have grown by leaps and bounds. Hence, the strictest economy plainly is indicated and should be enforced rigidly.

Let us establish clearly in our minds what the saving in copper means to our war effort. We are so used to large figures that a saving of one ton of copper in a large project may sound picayune and not worth the engineer's time. What is a ton of copper? At 12 cents a pound, 2,000 pounds is only $240. But these 2,000 pounds will make 80,000 cartridge cases for machine guns or rifles. Even if only one per cent of these rounds of ammunition reach their goal, there will be 800 fewer enemies facing us, and the end of the war will be that much nearer. Therefore, it is not the cost of copper that counts, but its availability. A market quotation is a poor yardstick to measure our effort in wartime.

The use of silver instead of copper in several war plants is one of the best illustrations of this point. Silver is approximately a seven per cent better conductor than copper, but it costs about 60 times as much. In normal times, its use has been limited to such relatively small but important parts as contacts of breakers and switches and the like. The bulk of our silver reserve was buried in government vaults, useless and sterilized.

War necessity forced on us a common-sense decision. An up-to-date electrochemical plant—such as used to produce aluminum or magnesium—requires a tremendous amount of electric equipment. For instance, a so-called electrolytic potline, capable of producing 30,000,000 pounds of aluminum per year, requires 60,000 amperes of direct current at 650 volts. As much as 1,000 tons of copper would be needed to carry this heavy current from one electrolytic cell to the next one and then back to the rectifiers. Aluminum could be substituted for copper but we need this metal badly elsewhere. And so, silver was taken out of its prison, rolled into heavy bus bars, and put to work. It is revealing to watch the construction men cut and trim these silver bars, and throw them around, seemingly without any respect, as if this were mere copper. True value shows up in an emergency.

But, interesting as this experiment is, we should not look to silver as an answer to our copper problem. Our supply of silver is large, if measured by the silver standards, but it is a drop in the bucket, less than two per cent of our annual copper consumption. In other words, we still must depend on copper to carry current. The problem of stretching our limited supply is still with us.

The next engineering step is obvious. Can we work our materials harder? Shall we temporarily discard our natural tendency to be conservative, and to play safe, in our designs and planning? The engineer's answer is a straightforward one.—Yes, let the equipment be overloaded if need be during this emergency. Let a 100-horsepower motor carry a 115- or 125-horsepower load; let the transformers, generators, cables, switchgear, and control carry an additional burden while the war lasts—just as our men and women in the services are doing and as our men and women on the home front are expected to do. This is the underlying idea of the War Production Board rulings on this subject. In this way, more useful equipment can be manufactured from the materials on hand and more materials will be left for the fighting services.

A certain amount of sincere opposition to this policy was naturally encountered. Would not this overloaded equipment be less reliable? Would not the resultant failures be more costly, in terms of lost production, than the realized savings in materials? At this point, common sense should be resorted to, as it is in all engineering problems.

A motor, overloaded as recommended, will have a shorter life, say 10 instead of 20 years, but this life span should be ample to cover the expected duration of the war. But within this life span, the expectancy of troubles and failures is not increased necessarily by the recommended heavier loading. Hence, overloading of this type makes sense. On the other hand, we may deal with a turbogenerator or a main transformer well past its prime of life, but still going strong. Overloading such a machine might invite trouble due to its aged insulation. A failure might result in the shutdown of a whole industrial area. It would be poor engineering judgment to foster overloading of this kind.

The greatest engineering contribution, however, is not only in finding alternates for critical materials, not only in working them harder, but in using them more *skillfully* and *efficiently*. War has stimulated this activity as nothing else had done before. Let us take, for instance, the field of electric-power distribution in industrial plants. It was not unusual to find that electric power would be brought to an industrial plant at high voltage, stepped down at the plant boundary to the motor voltage, and then distributed throughout the plant at this low voltage. No copper mine in the world contains as much copper as is buried in the cables and conductors in our industry. Copper was cheap, there was plenty of it, and few people worried over such waste.

Engineering analysis, applied to this problem, has shown convincingly that immense tonnages of copper can be saved by distributing power at high voltage (up to 13,800 volts) within the plants and by stepping it down to utilization voltage at several load centers, through the use of relatively small transformers. In a typical plant, with a 300,000-square-foot floor area and a load demand of about 3,000 kw, as much as 10,000 pounds of copper (the equivalent of 400,000 cartridge cases) can be saved by this method alone, without even attempting any overloading of the cables or the transformers. And, incidentally, a better operating system, with closer voltage regulation and with smaller losses, will be obtained. This is not a trick, it is merely the old story of making one pound do the work of two.

Or, let me cite the case of testing aircraft engines. Each engine is loaded and run for several hours to make certain of its performance in the air. The engines are rated up to 2,000 horsepower and use high-octane gasoline. It was considered normal to load these engines on propellers on a test stand, that is, to literally throw the energy into the air and waste expensive gasoline. The engineering solution now widely used is to connect the airplane engine under test to a generator and to pump the energy back into the power system. From 3,000 to 5,000 kilowatt-hours can be salvaged for each engine tested. If all airplane engines were tested in this way, as much as 1,000,000,000 kilowatt-hours could be salvaged per year and about 75,000 fewer tons of coal would have to be mined and transported. At several engine factories, up to 60 per cent of the energy required to operate the whole plant is obtained from this regenerative source. The load on the power systems is correspondingly reduced and these systems are more readily available to serve other industries without requiring additional generating and transmission equipment.

Again this is not a mere trick, but engineering at its best—engineering applied to war effort. Examples of such accomplishments can be found in practically all branches of industry.

Engineers should accept as a self-evident truth that no effort should be wasted on anything that will not help to win this war. But this does not mean that engineering developments and investigations should be stopped during the war. On the contrary, they should be stimulated. This war, more than any other in history, is a war of machines, of engineering. The side with the best engineering will win.

Remember, also, that this is a total war, fought in our factories as well as on the battlefield. Anything that will increase the war output of our plants may well deserve an engineering study, or even an engineering development.

A large steel mill in the Pittsburgh territory is working 100 per cent on war orders. It generates its own 25-cycle power. Increased production resulted in a power shortage. A public utility was ready to make up this shortage, but its system operates at 60 cycles. A 20,000-kw frequency-changer set was needed, and needed quickly. The electrical industry could not apply such a set within the needed time because the facilities for building large rotating machinery were tied up with other important war work, such as ship propulsion and the like. Yet the problem had to be solved. An electronic frequency changer was conceived, developed, and is being rushed to completion. Here is an instance of engineering development of the highest order, extremely important even in peacetime, but intimately and directly connected with the war effort.

Such cases could be cited without end. Add to these, the tremendous engineering developments connected with aircraft, radio, fire-control, and other combat equipment and it can readily be seen that in a nation at war the engineering profession must do a double duty in blazing new trails, trying new ideas, and venturing into the unknown. In this venture, co-operative effort is needed as never before. United we will accomplish so much more than we can individually.

Physical Metallurgy of Copper and Copper-Base Alloys

P. H. BRACE

The physical metallurgy of copper and some of its alloys is of particular interest to electrical engineers, since copper is used so widely in electric apparatus. Illustrations are given in this article of certain basic metallurgical phenomena determining properties and performance of some of the more specialized alloys with particular reference to the effects of elevated temperatures.

COPPER has been prized in all ages because of its favorable working characteristics. Pure copper can be cold-worked to an astonishing degree and may be effectively annealed at moderate temperatures. These facts are illustrated in a quantitative way by Figures 1 and 2 which show the effects of cold-rolling and annealing on the yield strength of high-conductivity oxygen-free copper (copper 99.94 per cent phosphorous nil) as reported by Wilkins and Bunn (page 11, chart 26, and page 12, chart 31).

From this it may be seen that the yield strength may be increased by approximately 5 to 1 by cold-rolling and that annealing is practically completed by heating for an hour at temperatures as low as 375 degrees centigrade.

From these data it may be seen that fairly good elastic strength may be conferred on pure copper by cold-working it. It is also apparent that a large part of this strength easily may be lost by prolonged exposure to elevated temperatures. That is, the thermal endurance of pure copper is quite low.

Early workers in copper were aware of the fact that the response of copper to cold-work and annealing was not uniform. In more recent times it has been found that quite small amounts of certain metals in solid solution in copper would alter profoundly its response to annealing after cold-working.

In modern electrical apparatus the temperatures reached by buried copper may be so high that the thermal endurance of pure copper is inadequate. Consequently, the effects on thermal endurance of small amounts of alloying elements has received a great deal of attention from those interested in the design of high-duty power apparatus.

Silver, even in quite small quantities, considerably increases the thermal endurance of cold-worked copper and, fortunately, has little effect on electrical conductivity. Figures 3 and 4 show data given by Gregg[2] on the effect of various small amounts of silver on the thermal endurance of hard-drawn copper wire. Moore,[3] in a discussion of the effects of temperature on overhead transmission lines, presents data to show that at 100 degrees centigrade silver-free copper wires soften almost completely in 100 days.

Arsenic and more recently tellurium have been used to improve the thermal endurance of cold-worked copper. The effect of the latter element may be seen by comparing Figure 5 (Wilkins and Bunn, page 25, chart 69) with Figure 2. The presence of 0.45 per cent tellurium has pushed the "knee" of the curve yield of strength versus annealing temperature for one-hour anneals from approximately 290 degrees centigrade (554 degrees Fahrenheit) to 320 degrees centigrade (608 degrees Fahrenheit) an increase of 30 degrees centigrade.

These gains in thermal endurance are helpful in dealing with the effects of usual operating temperatures. However, something more is needed when higher temperatures must be dealt with and where both electrical and mechanical duties must be performed by machine components, such as slip rings, spot-welding electrodes, and fuse clips, for example, where high conductivity is required.

This "more" has been found by the metallurgist in precipitation-hardening alloys. These are distinguished from the solid-solution alloys, for example, the dilute alloys of copper with tin, zinc, and nickel, which constitute the bulk of the standard engineering alloys of copper.

In a solid-solution alloy the atoms of the solute metal replace a proportion of the solvent atoms without disturbing greatly the crystal-lattice characteristic of the solvent metal. The alloy generally is harder than the pure metal. Unfortunately, when the alloy atoms are in solid solution they exert their maximum effect in decreasing electrical conductivity. The gain in strength arising from alloying is usually much less in proportion than is the loss in conductivity.

In precipitation-hardening alloys the solid-solution condition is stable at high temperature but not at low. If such an alloy be quenched from an appropriate elevated temperature, the solid-solution condition may be retained at room temperature. This condition is unstable however, and, if opportunity is given, as by reheating and holding at an intermediate temperature, the solute atoms will group themselves to form more or less definite crystallites within the mass of former solvent metal. This is the "precipitation" phenomenon. The tendency is for the solid solution to become transformed to a mechanical mixture. It appears that in the early stages of the precipitation process the solute atoms migrate into positions which cause sufficient disturbance of the regularity of the solvent lattice to affect markedly the mechanical properties in the direction of increased hardness and elastic strength

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Essential substance of a conference paper presented at the AIEE national technical meeting, Salt Lake City, Utah, September 2–4, 1943.

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Information for this paper, some of it unpublished, was supplied by various members of the staff of research laboratories, Westinghouse Electric and Manufacturing Company, particularly, E. A. Davis, A. Nadai, P. R. Toolin, P. G. McVetty, and T. F. Hengstenberg.

Table I. Physical Constants of Copper

Chemical symbol	Cu
Atomic number	29
Mean atomic weight	63.57

	Atomic Number	Atomic Weight	Abundance
Isotopes	29	63	68
	29	65	32

Melting point (degrees centigrade)	1,083
Boiling point (degrees centigrade)	2,310
Density (grams per cubic centimeter)	8.94
Crystal type	Face-centered cubic
Size of unit cell (centimeters)	3.6077×10^{-8}
Thermal conductivity (watts per square centimeter per centimeter per degree centigrade per centimeter, 20 C	3.82 at 0 C 3.81 at 20 C 3.72 at 200 C
Electrical resistivity (ohm-centimeters, 20 C)	1.682×10^{-6}
Temperature coefficient of electrical resistivity ohms per ohm per degree centigrade	0.00393
Wiedemann–Fránz ratio, 20 C, $\left(\gamma=\frac{k}{\sigma T}\right)$ (See Figure 24)	2.19×10^{-8}
Thermal expansivity (millionths per degree centigrade)	15.89 at 0 C 16.12 at 20 C 18.16 at 200 C
Magnetic susceptibility	-0.085×10^{-6}

Table II. Mechanical Properties of High-Conductivity Oxygen-Free Copper Strip, 0.04-Inch Thick[1]

	Hard	Soft
Tensile strength (pounds per square inch)	50,000–56,000	32,000
Apparent elastic limit (pounds per square inch)	38,000–43,000	3,000
Yield strength 0.5 per cent extension (pounds per square inch)	47,000–55,000	8,000
Yield strength 0.2 per cent offset (pounds per square inch)	47,000–54,000	6,000
Yield strength 0.1 per cent offset (pounds per square inch)	45,000–52,000	6,000
Elongation, per cent in 2 inches	3	43
Hardness, Rockwell *B*, 1/16-inch ball 100-kilogram load	53–59	
Young's modulus of elasticity (pounds per square inch)	16,000,000	

Table III. Mechanical Properties of Aged Copper-Chromium Alloy

	Aged	Aged and Cold-Rolled
Ultimate tensile strength	55,000	64,000
Apparent elastic limit	30,000	50,000
Elongation in 2 inches	30 per cent	15 per cent

of the alloy; that is, the hardening effect per solute atom is then much greater than for the solid-solution condition. At the same time the obstructive effects on current flow are decreased.

In some cases the net result is a large increase in both mechanical strength and electrical conductivity as compared with those of the quenched alloy. If the precipitation process is carried too far, the crystallites grow, and the special hardening effects associated with their initial extremely minute size disappear. Then they behave merely as so much finely divided foreign material in a plastic matrix: The alloy loses most of its extra hardness and becomes rather uninteresting.

In the electrical field precipitation-hardening effects are displayed to special advantage by copper-chromium and copper-chromium-silver alloys in which the chromium and silver contents may lie in ranges between approximately 0.3–1.0 per cent and 0–0.1 per cent, respectively. The valuable properties of these alloys arise primarily from the chromium, the silver, when used, acting as a useful auxiliary.

Figure 6 shows the effect on electrical conductivity of increasing the amount of chromium in solid solution in copper by quenching a fully precipitated 0.85 per cent copper-chromium alloy from various solution temperatures. The decrease in conductivity from 85 to 33 per cent is striking. Quenched from 1,000 degrees centigrade, this alloy would show an apparent elastic limit of less than 5,000 pounds per square inch, and elongation of 45 per cent in two inches, properties comparable to those of annealed pure copper. The results of carrying out the precipitation or "aging" process at 450 degrees centigrade are shown by Figure 7. Both hardness and conductivity rise, and both are still increasing after more than 500 hours at 450 degrees centigrade (842 degrees Fahrenheit). The aged alloy will show approximately the mechanical properties given in Table III. Despite the increase in strength the ductility remains relatively high.

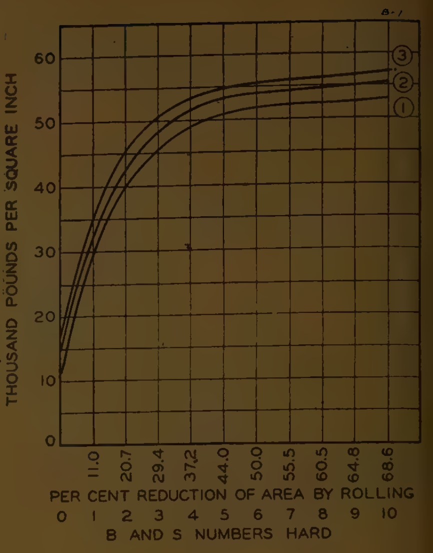


Figure 1. The effect of cold-rolling on the yield strength of oxygen-free copper strip (no residual deoxidant) previously annealed to a grain size of 0.015 millimeter (99.94 per cent copper—0.040-inch stock)

① *0.10 per cent yield strength (offset)*
② *0.20 per cent yield strength (offset)*
③ *0.50 per cent yield strength (extension)*

The thermal endurance of the alloy in the hard high-conductivity condition is enormously greater than that of any copper-base solid-solution alloy of comparable strength. Even when cold-working is utilized to enhance the strength of the precipitation-hardened alloy, the thermal endurance remains high.

This and the beneficial effects of a small addition of silver are shown by Figures 8 and 9 which indicate the effects of cold-work and tempering on the hardness of precipitation-hardened copper-chromium and copper-chromium-silver alloys. The relatively low stability of the severely cold-worked material should be noted. This is a general phenomenon. In the copper industry it has long been known that it is difficult to obtain "dead-soft" anneal of lightly cold-worked copper. Similar effects are noticeable in ferrous alloys.

Beryllium-copper alloys exhibit precipitation-hardening effects similar in character to those previously described but of different magnitude. In this case not all the alloying metal (beryllium) can be precipitated. Thus the precipitation-hardening effects are superposed on the solution-hardening effects of the residual beryllium in solid solution (the latter are unusually large for a solid solution) with the result that the tensile properties are higher and the electrical conductivity much lower than for the copper-chromium alloys.

Figures 10 and 11 after Rimbach[4] show the general characteristics of beryllium-copper alloys.

Precipitation-hardening characteristics intermediate between those due to chromium and to beryllium result from the addition of approximately two per cent each of cobalt

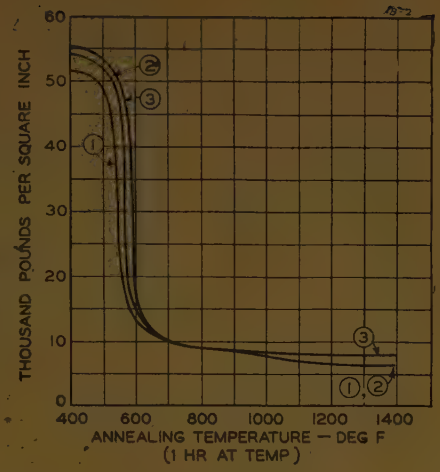


Figure 2. The effect of annealing on the yield strengths of oxygen-free copper strip (no residual deoxidants) previously cold-rolled to number 6, B and S gauge, (50 per cent reduction of area) from a material having a grain size of 0.015 millimeter (99.94 per cent copper—0.040-inch stock)

① *0.10 per cent yield strength (offset)*
② *0.20 per cent yield strength (offset)*
③ *0.50 per cent yield strength (extension)*

and iron to copper. Beryllium in small amounts gives higher hardness and lower conductivity. A general idea of the electrical and mechanical properties of such alloys is given by Figure 12 which shows the hardness and conductivity as related to heat treatment for copper-chromium, copper-iron-cobalt, and copper-iron-cobalt-beryllium alloys.

CREEP AND FATIGUE IN HIGH-STRENGTH HIGH-CONDUCTIVITY ALLOYS

So far attention has been directed to the properties at room temperature as affected by alloying and thermal and mechanical manipulations. The electrical designer is becoming more and more concerned with the behavior at high temperatures of his materials when subject to sustained as well as repeated loading.

Davis[5] has recently published the results of a careful investigation of the creep of oxygen-free high-conductivity copper at various temperatures and over fairly long test periods.

Davis describes the preparation of his material as follows:

> "Approximately 60 lengths of oxygen-free high-conductivity copper, each 4 ft. long 0.2 in. diam., were obtained from the Scomet Engineering Company. The rods were packed in a steel channel beam and annealed at 500 C for one hour. About one hour was required for the heating period, and several hours were required for cooling in the urnace. The annealing was done in an atmosphere of itrogen which had been assed over hot copper chips and activated alumina to remove the moisture and oxygen. The annealed copper appeared fairly clean and had an average Vickers hardness of 49.
>
> 'Each bar was prestretched 3 per cent before it was tested.

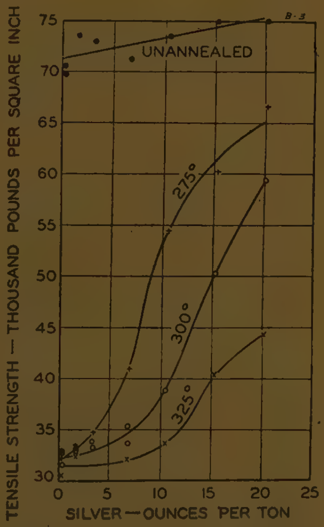


Figure 3. Tensile strength of 24-gauge (0.020-inch) wire annealed for two minutes at temperatures shown

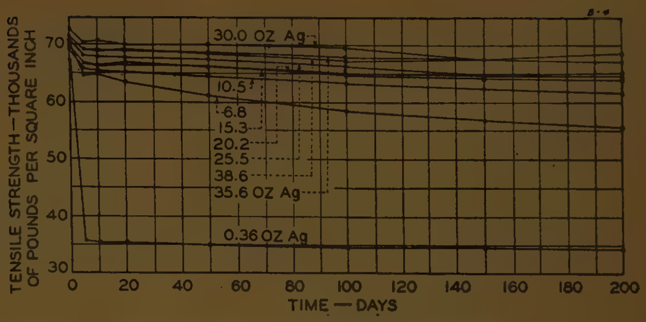


Figure 4. Effect of silver on softening of 16-gauge wires at 150 degrees centigrade

The figures on the curves indicate the number of ounces of silver per ton of copper which the wires contain

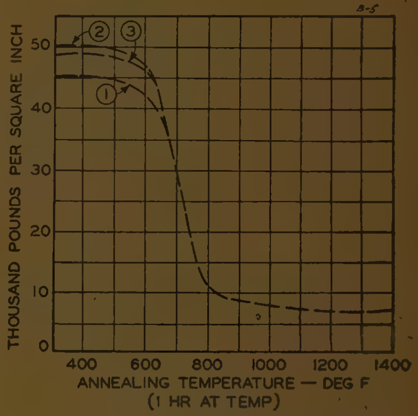


Figure 5. The effect of annealing on the yield strength of tellurium copper rod previously cold-drawn 50 per cent (reduction of area) from material having a grain size of 0.025 millimeter (0.45 per cent tellurium, remainder copper—rod under one inch in diameter)

① *0.10 per cent yield strength (offset)*
② *0.20 per cent yield strength (offset)*
③ *0.50 per cent yield strength (extension)*

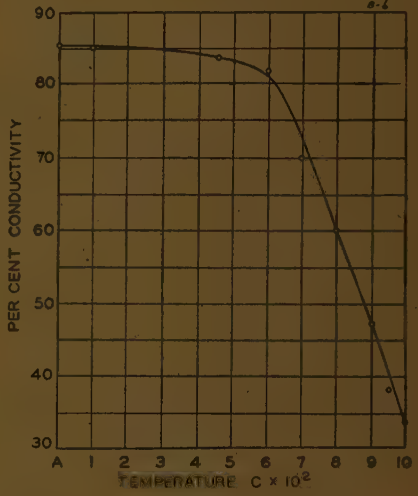


Figure 6. The effect of quenching from various temperatures on the conductivity of a copper-chromium alloy containing 0.83 per cent chromium

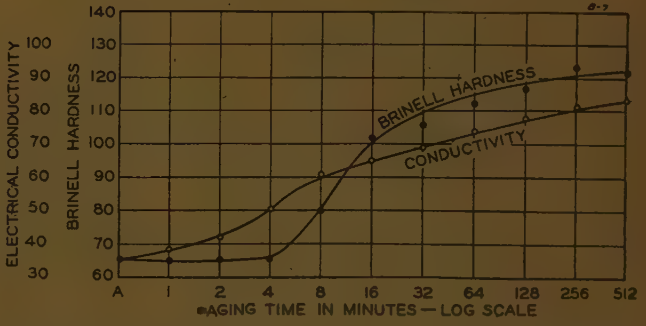


Figure 7. The rise of hardness and conductivity during the first stages of aging of an alloy containing 0.8 per cent chromium (quenching temperature 950 degrees centigrade; aging temperature 450 degrees centigrade)

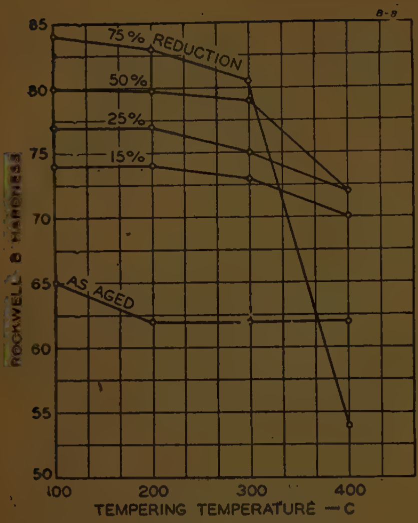


Figure 8. Curves of temperature versus hardness for Cupaloy 3144—0.40 per cent chromium, 0.007 per cent silver, 0.007 per cent silicon—tempered for four days

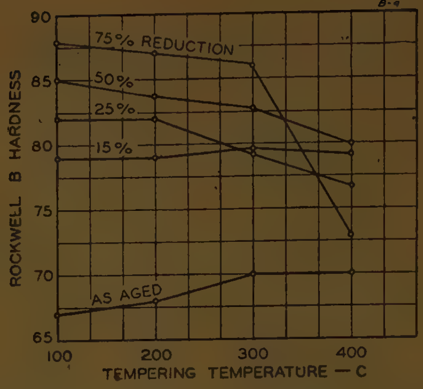
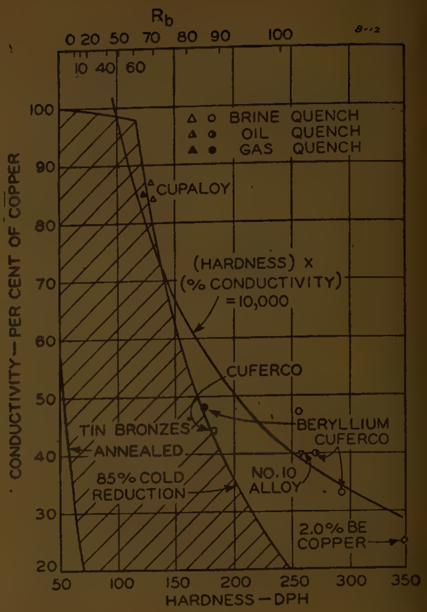


Figure 9. Curves of temperature versus hardness for Cupaloy 3145—0.36 per cent chromium, 0.064 per cent silver, 0.005 per cent silicon—tempered for four days

Figure 12 (right). Comparison of precipitation-hardened copper alloys with cold-worked bronzes



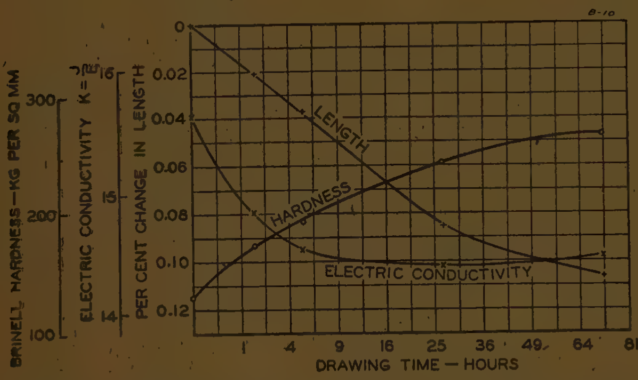


Figure 10. Change in length, conductivity, and hardness of a quenched beryllium-copper alloy with 2.5 per cent beryllium on drawing at 200 degrees centigrade

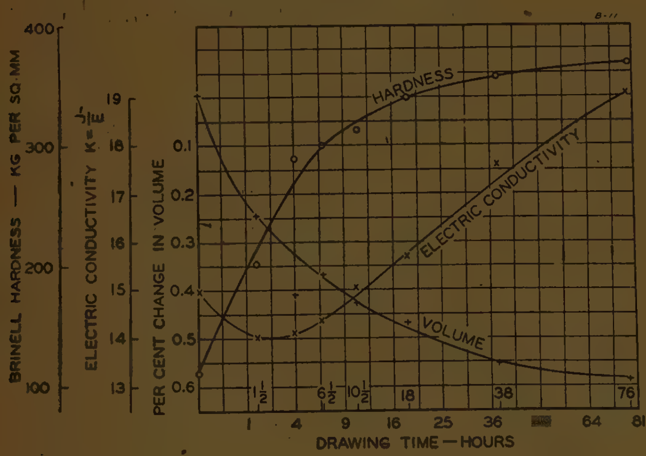


Figure 11. Change in volume, conductivity, and hardness of a quenched beryllium-copper alloy with 2.5 per cent beryllium on drawing at 250 degrees centigrade

The prestretching was all done at the same rate of strain. The true stress at 8 per cent strain at room temperature was about 23,500 psi. All stresses used in the tests were well below this amount in order not to produce large strains at the beginning of the tests."

The high lights of his results are shown by Figures 13 through 15.

From the curves it may be noticed that creep rates increased much more than proportionally with both load and temperature and that slow creep occurred at room temperature at stresses as low as 5,610 pounds per square inch. Relaxation test indicated that at room temperatures the stress would fall from 22,170 to 18,000 pounds per square inch in 1,000 hours and from 4,530 to approximately 4,000 pounds per square inch in like time. Figure 16 shows some more recent unpublished results from Davis which show that small amounts of silver greatly decrease creep rates at 200 degrees centigrade. At 8,330 pounds per square inch and with no detectable silver the minimum creep rate was 9.5×10^{-7} inch per inch per hour. With 0.078 per cent silver the rate at 8,310 pounds per square inch was only 1.4×10^{-7} inch per inch per hour—less than one seventh that for the unalloyed copper. Even at 9,820 pounds per square inch the rate was only 1.5×10^{-7} inch per inch per hour. Thus it appears that silver greatly benefits not only thermal endurance but high-temperature strength as well. Certain test data obtained by McVetty for 0.5 per cent copper-chromium alloy are shown by Table IV.

If we consider the data of Table IV for copper-chromium-silver alloy at 19,000 pounds per square inch and 100 degrees centigrade and make the conservative assumption that all the allowed plastic deformation occurs at a constant rate, the minimum creep rate for that alloy would be no more than 6.5 per cent of that estimated from Figure 15 for Davis' oxygen-free copper under like conditions. That is, one half of one per cent of chromium has increased the creep resistance of copper under those conditions by 1,500 per cent with a loss of conductivity of perhaps as little as ten per cent. Again there seems to be correlation between thermal endurance and creep strength.

The curves of Figure 15 were prepared by Davis tc summarize his creep results on high-conductivity oxygen-free copper. The estimate of the minimum creep rate a 19,000 pounds per square inch and 100 degrees centigrad was made by interpolating a curve representing the cree at 100 degrees centigrade between the experimentall determined curves for 80 degrees centigrade and 130 de grees centigrade respectively. This interpolated curv intersected the 19,000 pounds per square inch co-ordinat at a point corresponding to a minimum creep rate of 2 $\times$ 10^{-7} inch per inch per hour. This is 15.3 times the calcu

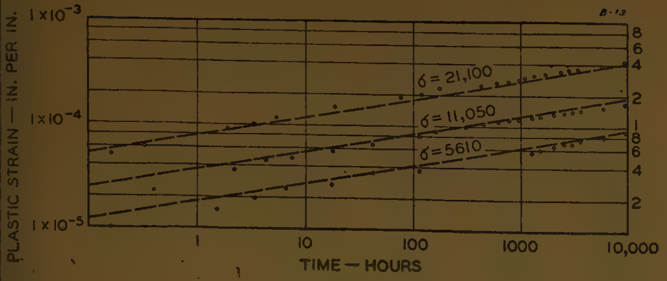


Figure 13. Creep curves for prestretched copper at room temperature

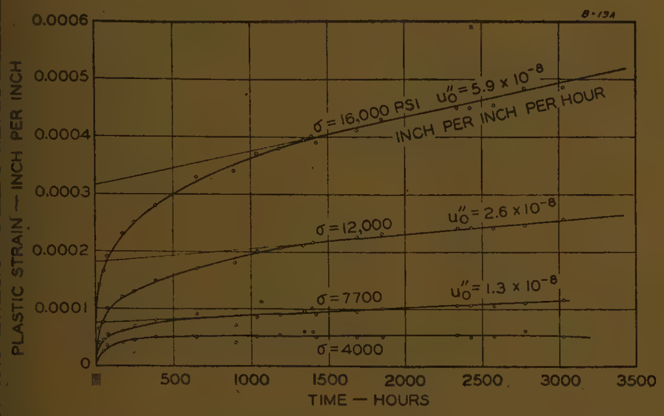


Figure 13A. Creep of oxygen-free copper at 80 degrees centigrade

lated uniform creep rate of 1.3×10^{-8} inch per inch per hour for the copper-silver-chromium alloy at 19,000 pounds per square inch and 100 degrees centigrade. The measured minimum creep rate for the copper-chromium-silver alloy was 1.25×10^{-8} inch per inch per hour.

FATIGUE AND ENDURANCE OF COPPER ALLOYS

Brittle fractures sometimes occur in copper parts which by conventional tests show no evidence of subnormal ductility. Such failures are usually the result of "fatigue" under repeated stress resulting from vibration or other cyclic loading. On the whole, the mechanical endurance of metals runs roughly parallel with tensile strength, and, despite its high ductility, soft copper may fail by fatigue at relatively low stress. For tough-pitch copper Wilkins and Bunn give the values of fatigue strength for 10^8 reversals shown in Table V.

Table VI shows data on tough-pitch copper annealed and cold-rolled and on a precipitation-hardened copper-chromium-silver alloy (chromium 0.5 per cent, silver 0.1 per cent).

The age-hardened copper-chromium-silver alloy has double the endurance of the cold-worked copper and approximately 90 per cent of its conductivity.

Figure 17 shows the results of several high-temperature fatigue tests by Toolin on forged heat-treated copper-chromium-silver alloy.

These results indicate that at 260 degrees centigrade (500 degrees Fahrenheit) fatigue strengths of the order of 25,000 pounds per square inch at 10^8 reversals are obtainable. That is a very satisfactory figure and is especially interesting in a high-conductivity alloy.

Toolin's tests were made in bending on round polished bars by means of a 120-cycle per second electrically driven

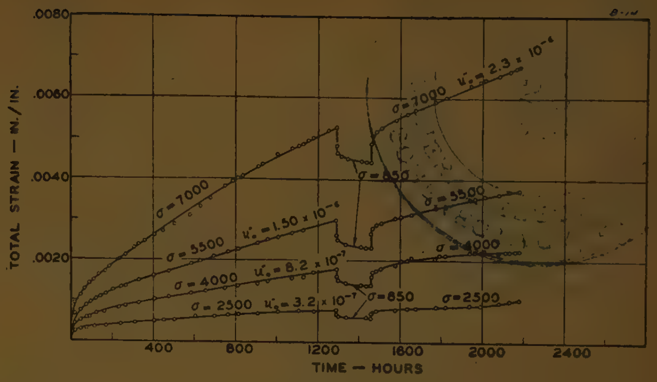


Figure 14. Creep of oxygen-free copper at 235 degrees centigrade

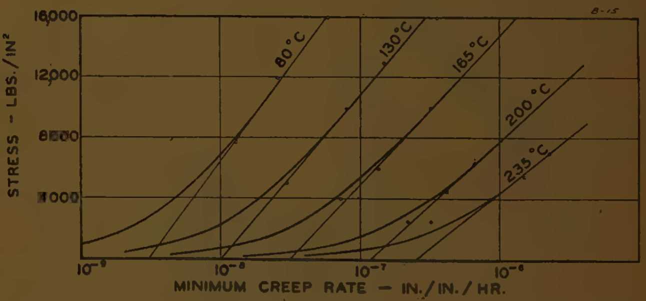


Figure 15. Stress–creep-rate relations for oxygen-free copper

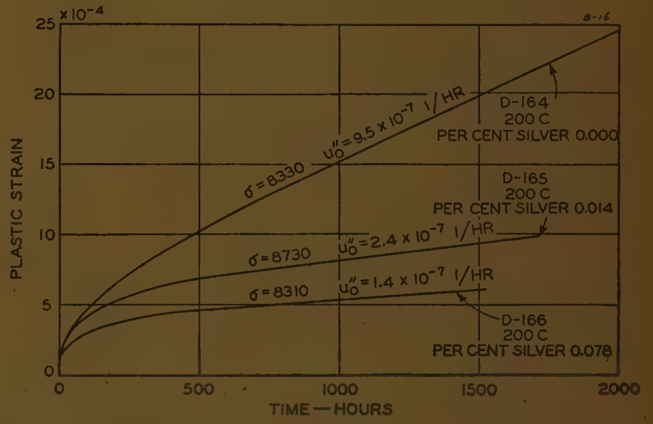


Figure 16. Creep curves for silver copper at 200 degrees centigrade

σ = stress, pounds per square inch
u″ = creep rate, inches per inch

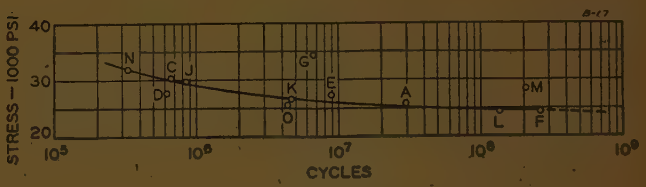


Figure 17. Cupaloy endurance curve at 500 degrees Fahrenheit (260 degrees centigrade)

120-cycle electromagnetic bending fatigue machines
Specimen: 0.505 inch in diameter
Material: forged Cupaloy
Heat treatment: water quench 1,000 degrees centigrade; aged 20 hours at 450 degrees centigrade
Tensile strength: at room temperature, 53,000 pounds per square inch; at 500 degrees Fahrenheit, 35,000 pounds per square inch

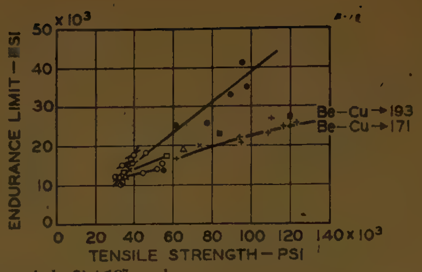


Figure 18. Endurance limit versus tensile strength for copper-base alloys

Minimum endurance ratio for strip = 0.20 approximately

○ *Copper, strip*
♂ *Copper-phosphorus, annealed, 2×10⁷ cycles*
□ *Copper, arsenical, tough-pitch*
△ *Gilding metal strip, 10⁸ cycles*
× *Red brass, rod, 10⁸ cycles*
✚ *Nickel-silver, strip, 10⁸ cycles*
● *Copper-nickel, rod, 10⁸ cycles*
⊙ *4 per cent phosphorus bronze, strip*
■ *Beryllium-copper strip, 10⁸ cycles*
◆ *Copper-chromium-silver*

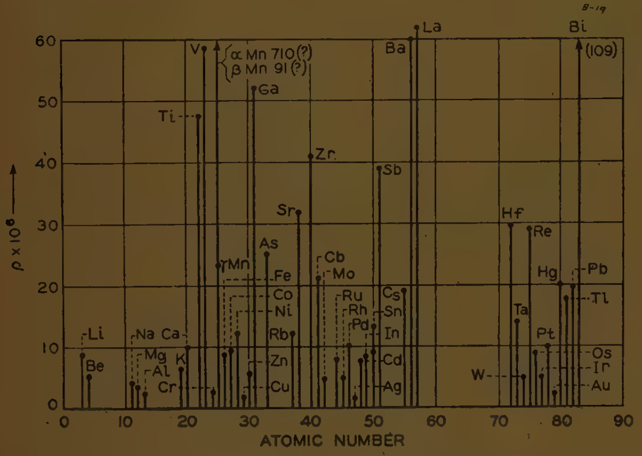


Figure 19. The resistivity of monatomic metals

The ordinates are expressed in ohm-centimeters

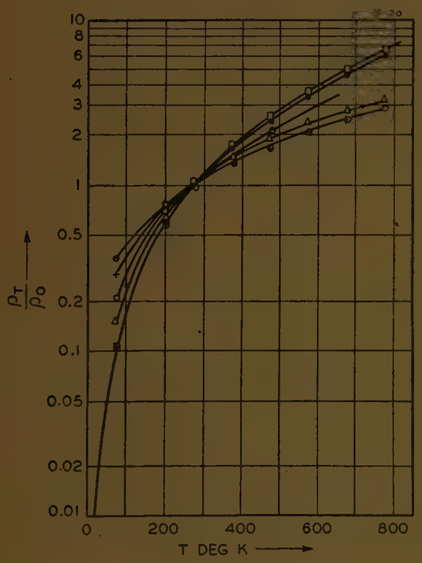


Figure 20. Temperature dependence of the relative resistivities of several metals

The ordinate is the ratio of the resistivity at temperature T to that at zero degrees centigrade

● *Iron*
□ *Nickel*
○ *Platinum*
△ *Copper*
✚ *Magnesium*
■ *Bismuth*

testing device. Temperatures and amplitude are controlled automatically, and loading is stopped automatically as soon as fatigue cracks start. Thus the fatigue process can be "caught in the act" and the specimen removed for study before failure has become extensive. The relatively high stress frequency greatly shortens testing time, a point of considerable importance.

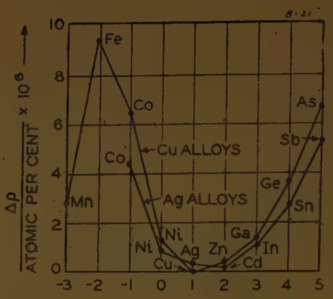


Figure 21. The increase in resistivity of copper and silver alloys per atom per cent of solute

The abscissa is the number of valence electrons of the solute atom relative to the closed d shell

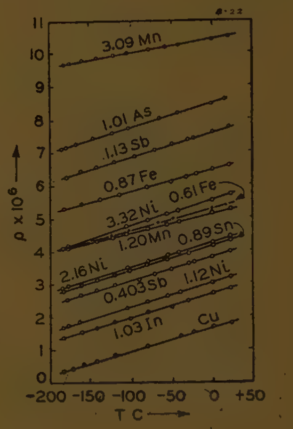


Figure 22. Curves of resistivity versus temperature for a number of copper alloys in the range in which the resistivity of copper varies linearly with temperature

It should be observed that the resistivities of the alloys are much higher than that of copper at low temperatures, implying very large residual resistivities. The resistivities are expressed in ohm-centimeters. The numbers indicate the atomic per cent of the alloying metal (after Linde)

Copper-beryllium alloys properly heat-treated show remarkably high mechanical endurance and for this reason are quite widely used for springs and other parts subject to repeated loading. The electrical conductivity of these alloys as heat-treated is about 30 per cent, quite high enough to be interesting for electromechanical applications. Figure 18 is an arrangement of data from Wilkins and Bunn intended to give some perspective of the relation between tensile properties as ordinarily determined and mechanical endurance for a number of copper alloys.

It seems worth-while to emphasize the fact that the relatively high ductility of copper and copper-base alloys is no guarantee against fatigue failure at notches, inadequate fillets, toolmarks or other points of stress concentration. It is true that the more ductile metals will settle down by localized plastic flow in a way not possible in brittle materials. However, in high-speed apparatus the number of stress cycles rapidly mounts into the millions, and the engineer, designer, and shop should be alert to the little circumstance that might cause a big failure. Mechanical stress is just as pervasive as electrical stress and, especially when oft repeated, can cause failures from pin-point defects just as certainly as do electrical stresses.

ELECTRICAL AND THERMAL CONDUCTIVITY, TEMPERATURE, AND COMPOSITION

With the exception of silver, copper has the lowest electrical and thermal resistivity of all the elements. Figure 19[7] shows the standing of copper among the metals as to resistivity at ordinary temperatures. It is interesting to note the periodic rise and fall of electrical resistivity with increasing atomic number.

The effect of temperature on the resistivity of copper and a few other metals is shown by Figure 20.[7] Despite their low resistivity, neither copper nor silver becomes a superconductor at low temperatures. Columbium, lead, and zinc are conspicuous because of the relatively high tem-

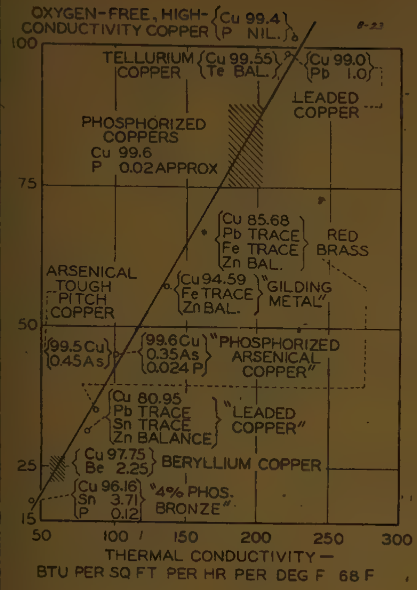


Figure 23. Copper alloys—relation between thermal and electrical conductivity (after Wilkins and Bunn)

eratures at which they show superconductivity, namely 22, 7.86, and 7.2 degrees Kelvin, respectively.

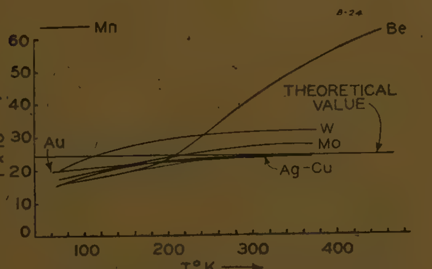
Figure 21[7] shows the effects on silver and on copper of nall quantities of a number of alloying elements in lid solution. The similarity of the reactions to alloying silver and copper is striking.

The electrical resistivity of copper containing even nall percentages of other metals in solid solution is alays higher than that of the pure metal and appears to e composed of two parts: one, apparently characteristic copper, which is responsive to temperature; and nother, due to the presence of the foreign atoms, which is nly slightly affected by temperature. These facts are lustrated by Figure 22[9], where it may be seen that the opes of the various temperature-resistivity curves are pproximately the same whatever their level on the restivity scale.

There is a rule of thumb which states that for most etals and alloys thermal conductivity is proportional to ectrical conductivity. How well this holds for a number copper-base alloys is shown by Figure 23 based on the ata of Wilkins and Bunn. That this rule is not a law may e seen from Figure 24, reproduced from Seitz (page 177). espite the abnormalities of some of the metals, it can be id that the thermal conductivity of the dilute copperase alloys for most engineering purposes may be taken s proportional to the electrical resistivity. This relation usually expressed by the Wiedemann-Franz law

$$= \frac{k}{T\sigma} \qquad (1)$$

igure 24. The Viedemann - Franz atio for several metals



he ratio r ($r = k/T\sigma$) given in units in hich σ is measured in ims^{-1} centimeters^{-1}, k measured in watts deees^{-1} centimeters^{-1}, and T is the absolute temperature. The theoretical value is 2.45×10^{-8} watt-ohm per degree[2]

Table IV. Comparative Creep Data for Cupaloy and Copper—Estimated Stress for a Service Life of Ten Years

Allowed Total Deformation (Per Cent)	Elastic* Deformation at Rated Stress (Per Cent)		Allowed Plastic Deformation at Rated Stress (Per Cent)		Rated Stress (Pounds Per Square Inch)	
	Cu	Cu-Cr-Ag	Cu	Cu-Cr-Ag	Cu	Cu-Cr-Ag
0.25	0.08	0.13	0.17	0.12	11,800	19,000
0.50	0.097	0.19	0.403	0.31	14,300	27,800
0.75	0.105	0.224	0.645	0.53	15,700	33,400
1.00	0.113	0.250	0.887	0.75	16,800	37,000

* Young's modulus $= 14.9 \times 10^6$ pounds per square inch.

Table V. Fatigue Strength of Tough-Pitch Electrolytic Copper

Condition	Stress for Failure at 10^8 Reversals (Pounds Per Square Inch)	Tensile Strength (Pounds Per Square Inch)
Soft	11,000	$30–35 \times 10^3$
Hard, 2 *B.* and *S.*	13,000	$40–45 \times 10^3$
Hard, 8 *B.* and *S.*	14,000	$55–57 \times 10^3$

Table VI. Fatigue Strength of Copper and Copper-Chromium-Silver Alloy

Material	Fatigue Strength	Relative Endurance
Copper, annealed	9,500	1.00
Copper, cold-drawn 15 per cent	12,000	1.26
Copper-chromium-silver alloy (chromium 0.5 per cent, silver 0.1 per cent nominal)	21,500	2.25

where T is the absolute temperature, σ is measured in ohms^{-1} centimeters^{-1}, k in watts degrees^{-1} centimeters^{-1} and γ is the Wiedemann-Franz ratio. The theoretical value of $k/T\sigma$ is 2.45 watt-ohms/deg.[2]

Rearranging equation 1 and substituting the numerical value for γ gives

$$\frac{k}{\sigma} = 2.45T$$

That is, the ratio of thermal conductivity to electrical conductivity increases with the absolute temperature. In other words, the temperature coefficient of thermal resistivity is less than that of the electrical resistivity.

In developing this article I have emphasized the effects on copper of elevated temperatures and of small alloy additions, because it has seemed that in those directions lay, respectively, the more pressing engineering problems and the greatest possibilities of satisfactory answers.

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Effect of High-Frequency Fields on Micro-Organisms

HUGH FLEMING

Because of the many vague and conflicting reports on the effect of short waves on micro-organisms, the laboratory analysis reported in this article was undertaken; the author has endeavored to correlate the electrical data with medical and bacteriological data. Because of time and equipment limitations, the study shows trends in electrobiological treatment at high frequencies rather than conclusive evidence.

THE MEDICAL USE of high-frequency fields in producing artificial fevers has been recognized in Europe for 30 years. Medical men in the United States have used short-wave diathermy extensively for the last ten years. The basic pattern of use involves the exposure to a high-frequency field of an ailing portion of the body until the local temperature has been increased considerably. Heat is generated by the passage of eddy currents, hysteresis losses, and dielectric losses. The temporary rise in temperature is advantageous primarily because of the increased activity of disease-fighting components of the blood stream. Undoubtedly secondary effects exist, such as the outright killing of bacterial bodies unable to survive the rapid change of temperature and the rapid reversals of potential.

Two general methods of enveloping the body in the high-frequency field are used. The most common of these is placing the structure to be treated in the dielectric field existing between two small applicator plates. The second method is to cause an inductive circuit to conform to the necessary dimensions so that it completely envelops a body part. Here the magnetic field would play a large part, and hysteresis losses would seem to be large. The Fisher Scientific Company has made extensive tests on the relative heating efficiency of the two methods and has found the inductive method greatly superior.

Originally the value of high-frequency treatment of humans was credited only to the uniform and localized fever effects made possible. More recently, a study of the effects of short waves upon bacteria and other micro-organisms has shown that lethal effects are evidenced without appreciable rise in temperature. Haase and Schliephake reported that no comparison could be made between the temperature of water passing high-frequency currents of lethal value and the temperature of hot water required to produce the same immobilizing action. This makes evident the existence of additional effects of germicidal value.

High-frequency currents between the limits of 9,000 and 100,000 kilocycles are of recognized medical value. Generation is accomplished by means of vacuum-tube oscillators much in the same manner as for radio broadcast purposes. (See circuits in Figures 1 and 2.) In the literature, there are limited reports of attempts to immobilize micro-organisms in water media by the passage of high-frequency currents. Most of the work has been done by European doctors of medicine, with little presentation of what would be termed engineering data.

It can be stated definitely that all forms of microscopic life can be immobilized with short waves if treatment is severe enough. Bacteria, in particular, are said to be immobilized rather than killed because the only determination that can be made is a test of their power of reproduction. Failing to reproduce, bacteria are considered dead. If microscopic examination shows bacteria broken into component parts, it can be assumed that they have been destroyed. However, merely turning on enough power to obtain a lethal effect is not economically sound, and it is reasonable that there should be a search for optimum germicidal conditions.

Nearly all cell life can be speeded up in its rate of growth under the stimulus of high frequency. This action takes place at a progressively faster rate as the power is increased, until a point of overstimulation is reached and lethal effects occur. This point of overstimulation differs widely depending upon the age, virulence, and extent of colonization of the organism under study. A curve illustrating the rate of growth as a function of the power applied is given in Figure 3.

Haase and Schliephake were able to immobilize both streptococci and staphylococci with waves from 3 to 20 meters. Hicks was unable to destroy these same bacteria with 4.5 meter waves. It is interesting to note that he reported his cultures contained salt, which increased the conductivity of the water. Liebesny, using 20- to 30-meter waves, stated at the same time that bacteria were killed in reciprocal proportion to the increase of electrolyte introduced. From his experiments he claimed that the effect on a certain electrolyte is optimum (using a rise in temperature as the standard), when the dielectric properties have a definite mathematical relationship to frequency. He wrote an equa-

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Essential substance of a paper, "A Study of the Effect of High-Frequency Fields on Micro-Organisms," which was awarded the AIEE national prize for Branch paper for the academic year ending June 30, 1942. The paper was presented at a joint meeting of the Portland (Oreg.) Section and the Oregon State College Branch, Corvallis, May 16, 1942.

Hugh Fleming was an enrolled student at Oregon State College, Corvallis, when the paper was presented. He is now a student engineer, General Electric Company, Schenectady, N. Y.

The author acknowledges the assistance of the Oregon State College department of bacteriology.

tion for this: $K = f/(cx)$, where f represents frequency, c, the dielectric constant, and x, the reactance.

Schmidt and Hoensdorf found that streptococci and Escherichia coli were materially retarded in their growth in a moderate high-frequency field if localized. They reported good results at 4.6 meters in the presence of physiological salt or boric-acid solutions. Fabian and Graham tested bacillus coli and found that 30 meters with a current of 0.8 ampere produced death. They cautioned against concluding, immediately on the immobilizing of bacteria, that they had been successfully killed as . . . "a seemingly lethal effect may be followed in a few days by a rapid and intensive growth." Tibor de Cholnoky indicates a correlation of media and lethal dosage. He states that water-borne bacteria are more difficult to immobilize than those in some other media such as air.

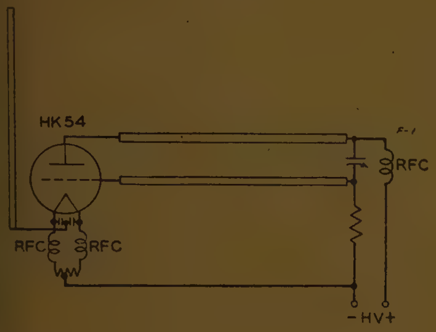


Figure 1. Schematic diagram of a vacuum-tube oscillator for 90-centimeter waves

Two theories have been proposed explaining the mechanics of rendering a culture of micro-organisms nonviable. The first of these is that the instantaneous temperature of the bacteria, or other life, can be raised to a very high value without necessarily affecting the surrounding media to a great extent. The assumptions are that the hysteresis, eddy current and I^2R losses are very great in the matter making up the cell. If this theory were true exclusively, it would appear that the effectiveness should be proportional to the frequency. As was pointed out already, there is a definite frequency band of optimum value above which the immobilizing effects diminish.

The second theory explaining the lethal action of short waves involves the possibilities of mechanical stresses. Nearly all bacteria have a negative charge. It is believed that a condition of mechanical resonance is reached at certain frequencies that so distorts the organic matter of the micro-organism that it is rendered nonviable. This would imply that the high-frequency field acts powerfully enough upon a bacterium, for instance, to cause it to travel a minute distance first in one direction and then in the reverse direction as the field is changed. These oscillations of the tiny bits of matter might well become so rapid as to exceed the elastic limits of the structure of the organism. Since different types of bacteria have entirely different physical dimensions as well as properties, it follows that the frequency of best destructive power would vary for each different type of cell treated. This is true although the optimum frequency for a given type of single cell life is not as critical as might be supposed. Some microscopic evidence of actual bacterial destruction due to distorted masses has been reported.

The variables studied in the laboratory were: frequency, voltage, current, time, and conductivity of the media containing the micro-organisms. All were studied as a function of the immobilizing power of the high-frequency currents.

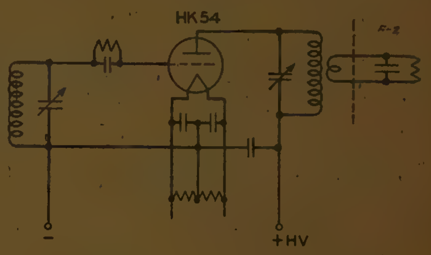


Figure 2. Schematic diagram of a vacuum-tube oscillator for 10–25-meter waves

VARIABLE-FREQUENCY TESTS

In the variable-frequency tests, numerical concentrations of bacteria were maintained as constant as was possible. An attempt was made to keep power outputs constant for all tests by means of flashlight lamps in parallel with a nonresonant line and the loading network. Measurement of light intensity of the lamps was made with a light meter. It is evident that such an arrangement would not measure exactly the output, but would give sufficiently relative values to enable significant data to be taken regarding the remainder of the variables. In all cases, standard six-inch fermentation tubes filled with a total of ten cubic centimeters of media and culture were used. Two oscillators were used. For the range 10–25 meters a tuned-plate tuned-grid Gammatron 54 supplied the power, and below the range of five meters to 90 centimeters a resonant-line oscillator was used. (See Figures 1 and 2.) Utilized power output on all frequencies was approximately ten watts. In no case was a significant rise in temperature permitted. The standard type of bacteria tested were Escherichia coli, which are nonspore-forming vegetative cells found quite commonly in polluted rivers and streams. All tests were made in the electric field existing between two condenser plates.

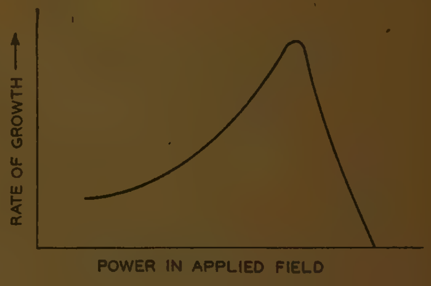
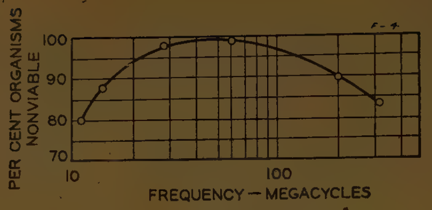


Figure 3. Rate of growth of cell life under stimulus of high frequency

By referring to the curve in Figure 4, it can be seen that all frequencies tested had somewhat of a lethal effect upon the Escherichia coli. This effect became noticeably peaked around 60 megacycles. A standard

Figure 4. Effect of frequency on Escherichia coli



Samples: 10 cubic centimeters; control: 450,000,000 per cubic centimeter. Maximum temperature: 85 degrees Fahrenheit. Exposure in dielectric field

time interval of one minute was used on all cultures. The frequency measurements were made by means of a radio receiver below 28 megacycles and by Lecher wires above 28 megacycles. Three samples and a control were taken for each of six frequency determinations (350, 200, 60, 28, 14, and 11 megacycles). Each fermentation tube was shaken before exposure to the high-frequency field to distribute the contents evenly and to assure uniform conductivity, and was plated immediately after exposure.

VARIABLE-VOLTAGE AND CURRENT TESTS

The theory holding that hysteresis and eddy-current losses in the high-frequency field raise the instantaneous temperature of a cell to a greater value than the surrounding medium would seem to indicate that the magnetic field plays the important part. On the other hand the theory of mechanical resonance implies that voltage gradients about the bacteria are important. Therefore a resonant line operating on 90 centimeters was devised of such dimensions that a fermentation tube could be placed either at a voltage node or a current node. Considerable unbalance in the oscillator was caused by the former instance, and relative values of power had to be supplied by adjusting the oscillator to a specific increase of plate-power input. For the tuning operations, sample tubes of Escherichia coli had to be used to simulate the anticipated load. Test conditions again involved a standard time interval of one minute and a wave length of 90 centimeters. From the following data it is evident that a large voltage gradient across the bacteria is more important than a high current or an intense magnetic field:

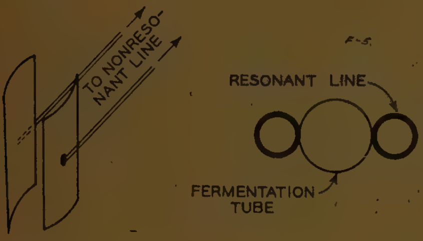
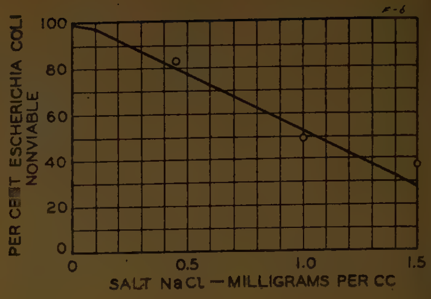


Figure 5. Arrangements for (left) passing a high current and (right) obtaining large voltage gradients

Sample	Average Count Per Cubic Centimeter
Control	450,000,000
High-current treatment	200,000,000
Voltage stressed	1,000,000

Figure 6. Effect of conductivity upon treatment of Escherichia coli



In two of the tests, the tubes of Escherichia coli were completely sterilized. The fermentation tubes filled with Escherichia coli acted very much like a portion of the resonant circuit. In one case a high current at a low potential drop made the tubes appear as a conductance, and in the other case a high potential drop caused the tubes to appear as a high resistance. An error was undoubtedly introduced by virtue of radiation from the large fins required for the current treatment. (See Figure 5.) However, it is believed that the tests made are sufficient evidence to support the generalization that obtaining voltage gradients within the solution is far more important than adjustment so as to pass a large radio-frequency current.

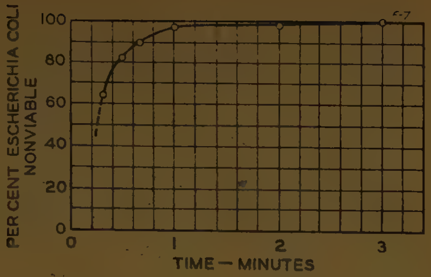
TIME-VARIABLE TESTS

All experiments with the element of time as a variable were made with constant-current values as indicated by a light meter and flashlight lamps as in the variable frequency tests previously considered. The power used was approximately ten watts. Standard six-inch fermentation tubes filled with ten cubic centimeters of Escherichia coli and media were used. During the first fraction of a minute almost all the bacteria are rendered nonviable. For the next few minutes, until the solution is completely sterilized, the lethal action appears to go on at a progressively slower rate. Thus, the instantaneous killing power might be written as a reciprocal function $y=1/t^x$, where t represents time. This is in accord with a cluster theory of bacteria which indicates that colonies become more numerous as smaller groups are considered. The larger colonies, while representing a small percentage of the total, present a different mechanical and electrical characteristic, and reduce the effectiveness of the high frequency treatment. The difference in numbers of the bacteria making up a colony as well as their individual size could explain very well the lack of a definite optimum frequency for treatment.

CONDUCTIVITY-VARIABLE TESTS

The question of the effect of variations in conductivity of the medium containing the bacteria to be tested could be approached a number of ways. Variation in the number of bacteria per cubic centimeter causes variation in the conductivity. The type of media in which they were grown may contain varying amounts of salt. In addition, electrolytes such as sodium chloride or boric acid may be added in appreciable quantities without harm to the Escherichia coli used.

Figure 7. Time of treatment of Escherichia coli



Samples: 10 cubic centimeters; control: 500,000,000 per cubic centimeter. Maximum temperature variation per sample: 70 to 110 degrees Fahrenheit. Exposure in dielectric field. Frequency: 28 megacycles

The latter method was used to demonstrate the effect of varying conductivity upon the immobilizing power of the high frequency. A frequency of 28 megacycles was used with an approximate power of ten watts. The dielectric field was used, and three concentrations of salt were added, (0.5, 1.0 and 1.5 milligrams per cubic centimeter). See Figure 6. The time of treatment was one minute.

The effects were evident at once. A higher concentration of electrolyte decreased the effectiveness of treatment. Again it appeared that high currents, although they generated heat more rapidly, would not give the results that a high-voltage stress would when conductivity and current were lowered.

CONCLUSIONS

It should be emphasized again that the experimental work was only developed to demonstrate trends in the immobilizing effect of the variables listed. Exact measurement of the actual energy dissipated within the fermentation tubes could not be made. Particularly was this true at the ultrahigh frequencies where the percentage of radiated power was appreciable.

The study undertaken showed that germicidal results were easy to obtain even with small amounts of power, and suggests that for some applications a consideration of sterilization by means of exposure to high-frequency fields is warranted economically. Also the possibilities of greatly speeding up life processes such as in yeast manufacture are evident. The best frequency to use for treating a given micro-organism depends upon the size of that organism. However, the bactericidal range can be roughly assigned to the 1–20 meter band.

It is possible that additional lethal effects might be experienced in the ultrahigh frequency range, but control is difficult when it comes to treating large masses of organic matter.

It is evident that a high potential gradient should be maintained for maximum effectiveness. This means that as little electrolyte as possible should be allowed in the presence of the high-frequency field. A high voltage necessitates a tuned circuit whose dimensions conform to the quantity to be treated.

The results of the time study suggest that it would be much more economical to use a large amount of power for a short time than a small amount of power for a long time. If sufficient power is used to immobilize the largest cluster of bacteria in a short interval of time, it appears that the remainder would be easily disposed of.

Toward the close of the experimentation a new technique in testing the effects of high frequency upon bacteria was devised which greatly speeded up the analysis. The method is suggested for further study and outlined as follows: The bacteria to be tested are plated out in countable concentrations on a number of petri dishes. Wires can be imbedded in the agar solutions used so as to remain fixed in the gelatinous mass. Controlled amounts of energy are then applied to the petri dishes and a direct count can be made of colonies the next day. A variation of this consists of omitting the wires and substituting two metal plates on the top and bottom of the petri dishes, arranged to conform to the latters' dimensions.

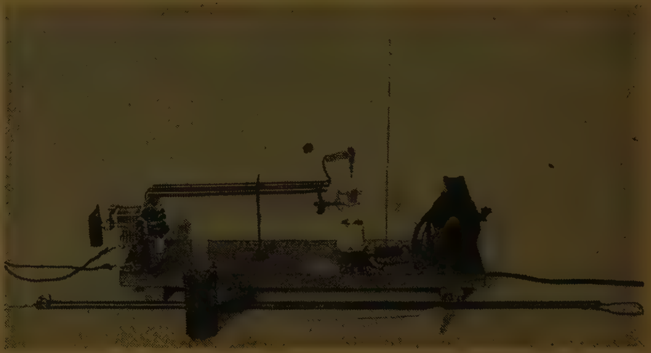


Figure 8. The 90-centimeter oscillator with the concentric line which coupled the radio-frequency energy to the specimens under test

The upright test tube is between two semicircular aluminum plates insulated by means of polystyrene spacers from a coil form. A parallel flashlight lamp is at the end of the concentric line at the left. This was used to maintain relative values of current in conjunction with a light meter as explained in the text

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INSTITUTE ACTIVITIES

Program Announced for Winter Technical Meeting, January 24–28, 1944

A program of 30 technical sessions and conferences, including a general session, has been arranged for the AIEE winter technical meeting to be held in New York, N. Y., January 24–28, 1943. Headquarters for the meeting will be in the Engineering Societies Building. In accordance with the wartime policy adopted by the board of directors, preference has been given to papers which are of aid in the war effort.

The winter technical meeting of the Institute of Radio Engineers will be held in the Hotel Commodore, January 28–29. The programs for the two meetings have been co-ordinated, with the AIEE communication and electronics session scheduled for Thursday afternoon, and a joint IRE–AIEE session Thursday evening, so as to provide three days of continuous interest for radio and communication engineers. The IRE annual business meeting, followed by a session of technical papers, will be held Friday morning. In the afternoon a symposium on work of the Radio Technical Planning Board will be held, followed by a session of technical papers. Awards will be presented at a banquet that evening, and there will be an annual address by the retiring president, L. P. Wheeler. Saturday morning a symposium of papers will be held, followed by a technical session in the afternoon.

JOINT IRE–AIEE SESSION

The principal speaker at the joint IRE–AIEE session, which will be held in the Engineering Auditorium on the evening of January 27, will be Major General Roger B. Colton, chief, engineering and technical service, Signal Corps, United States Army. The address will be on the subject of "Enemy Army Communications Equipment." Phases of the subject to be discussed by General Colton include the importance of communications in today's war with its speed of movement and the great distances involved, intelligence, how captured equipment is obtained and what is done with it, as well as a general statement of what has been found out about enemy equipment and what we have found out in the laboratories. Specific examples of equipment will be given, and general and specific comparisons will be made with the United States equipment. In conclusion, General Colton will specify some particular problem and explain how electrical and radio engineers can help in the solution of problems. After the address a display of communications equipment and photographs of captured equipment will be shown.

GENERAL SESSION

The Edison Medal will be presented to Vannevar Bush at the general session Wednesday morning, January 26. Doctor Bush was awarded the medal "for his contribution to the advancement of electrical engineering, particularly through the development of new applications of mathematics to engineering problems, and for his eminent service to the Nation in guiding the war-research program."

At the conclusion of the medal presentation ceremonies there will be a featured talk on a topic of interest to many members.

SMOKER

In order that those attending the winter technical meeting may have an opportunity to get together with their friends under conditions where all may relax and pass a thoroughly enjoyable evening it has been decided this year to have a "smoker," Tuesday evening, January 25, at the Hotel Commodore. Insofar as possible all conditions surrounding the popular affairs of previous years will be provided. Ticket, including dinner and show, will be five dollars per person. Tables for ten can be reserved by advance payment. Checks should be made out to "Special Account, National Secretary, AIEE."

THEATER TICKETS

As an accommodation to our out-of-town members attending the meeting, a limited number of theater tickets to popular shows will be available for purchase. Preference will be given to out-of-town orders. All tickets will be for Wednesday evening, January 26, not the 27th, as previously announced. Orders must be accompanied by checks made out to "Special Account, National Secretary, AIEE." If acceptable, an alternate selection should be named. Tickets at $4.40 each for the following shows have been reserved:

1. "One Touch of Venus"
2. "Winged Victory"
3. "Ziegfeld Follies"

Members will be advised of the disposition of their orders, and tickets will be held at AIEE headquarters.

PATENT EXHIBITION

A catalog of some 45,000 United States patents and patent applications in the mechanical, electrical, and chemical fields, formerly enemy-owned or enemy-controlled will be on exhibit during the meeting. These patents and patent applications are available for licensing under liberal terms, and Leo T. Crowley, Alien Property Custodian of the United States Government, under whose authority they are being shown, hopes that American engineers will realize the full potentialities of the inventions covered by these vested patents and patent applications by employing them in the war effort wherever possible and developing them for the postwar period.

A member of the Custodian's staff will be present to answer questions.

REGISTRATION AND HOTELS

Members who have received an advance registration card by mail should fill in and return the card promptly. Upon arrival at the meeting members who registered in advance should not fill in another card, but badges should be obtained. A registration

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Schedule of Events

Monday, January 24

9:30 a.m.	Transmission and distribution
9:30 a.m.	Electrical measuring instruments
9:30 a.m.	Conference on electric welding
2:00 p.m.	Power generation, transmission, and distribution
2:00 p.m.	Applications of electrical measurements and basic sciences
2:00 p.m.	Conference on marine transportation

Tuesday, January 25

9:30 a.m.	Transmission and protective devices
9:30 a.m.	Conference on turbogenerator characteristics
9:30 a.m.	Conference on measurement of temperature rise in continuous-duty machines
2:00 p.m.	Circuit breakers
2:00 p.m.	Land transportation
2:00 p.m.	Conference on permissible temperature of short-time rated machines
2:00 p.m.	Conference on speed relaying
6:30 p.m.	Smoker at the Hotel Commodore

Wednesday, January 26

10:00 a.m.	General session—Edison Medal presentation and feature talk
2:00 p.m.	Conference on lighting
2:00 p.m.	Relays
2:00 p.m.	Conference on industrial control
2:00 p.m.	Conference on civic affairs and co-operation with other organizations
2:00 p.m.	Meeting of safety committee

Thursday, January 27

9:30 a.m.	Air transportation
9:30 a.m.	Conference on domestic and commercial applications
9:30 a.m.	Conference on industrial power applications
2:00 p.m.	Air transportation
2:00 p.m.	Communication and electronics
2:00 p.m.	Industrial power applications
8:00 p.m.	Joint IRE–AIEE session

Friday, January 28

9:30 a.m.	Electrical machinery
9:30 a.m.	Conference on automatic stations
10:30 a.m.	*IRE annual business meeting and technical-papers session
2:00 p.m.	Transformers
2:00 p.m.	Conference on administrative problems in Army and Navy Specialized Training Programs
2:30 p.m.	*IRE symposium on work of the Radio Technical Planning Board
4:30 p.m.	*IRE technical-papers session
7:00 p.m.	*IRE banquet (informal)
8:15 p.m.	Teaching aids for Navy Specialized Training Programs

Saturday, January 29

9:30 a.m.	Special lecture at, and inspection trip through, the Brooklyn Navy Yard—open only to a specially selected and invited teaching personnel
10:00 a.m.	*IRE symposium of papers
2:30 p.m.	*IRE technical session

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* All IRE sessions at the Hotel Commodore, except the joint IRE–AIEE session, which will be held in the Engineering Auditorium.

Tentative Winter Technical Meeting Program

● **PAMPHLET reproductions of authors' manuscripts of the numbered papers listed in the program may be obtained as noted in the following paragraphs.**

● **ABSTRACTS of most papers appear on pages 25–31 of this issue and pages 545–7 of the December 1943 issue.**

● **PRICES and instructions for procuring advance copies of these papers accompany the abstracts. Mail orders are advisable, particularly from out-of-town members, as an adequate supply of each paper at the meeting cannot be assured. Only numbered papers are available in pamphlet form.**

● **COUPON books in $5 denominations are available for those who may wish this convenient form of remittance.**

● **THE PAPERS regularly approved by the technical program committee ultimately will be published in "Transactions;" many will appear in "Electrical Engineering."**

Monday, January 24

:30 a.m. Transmission and Distribution

4-53. Current Rating of Cables As Affected by Mutual Heating in Air or Conduit. **IPCEA committee on research**

4-54. Calculation of Unbalanced Voltage Drops n Distribution Circuits With Particular Reference o Multigrounded Neutrals. **W. R. Bullard, H. L. Lowe, H. W. Wahlquist,** Ebasco Services, Inc.

4-10. Transformer Magnetizing Inrush Currents nd Influence on System Operation. **L. F. Blume, G. Camilli, S. B. Farnham, H. A. Peterson,** General Electric Company

4-62. Costs Study of 69- to 345-Kv Overhead Power-Transmission Systems. **John G. Holm,** Boston Port of Embarkation

9:30 a.m. Electrical Measuring Instruments

4-21. A Multiplied-Deflection A-C Potentiometer. **R. B. Marshall,** Purdue University

4-4. An Instrument for the Measurement of Large Alternating Currents. **Walther Richter,** Allis-Chalmers Manufacturing Company

4-33. Crossed-Coil Power-Factor Meters. **N. P. Millar,** General Electric Company

4-31. Influence of Improved Magnetic Alloys on Design Trends of Electrical Instruments. **M. S. Wilson, J. M. Whittenton,** General Electric Company

9:30 a.m. Conference on Electric Welding

2:00 p.m. Power Generation, Transmission, and Distribution

44-15. Regulation of A-C Generators With Suddenly Applied Loads. **E. L. Harder, R. C. Cheek,** Westinghouse Electric and Manufacturing Company

44-12. Steady-State Stability of Synchronous Machines as Affected by Voltage-Regulator Characteristics. **C. Concordia,** General Electric Company

44-17. Lightning Protection for Rotating Machines. **G. D. McCann, E. Beck, L. A. Finzi,** Westinghouse Electric and Manufacturing Company

44-23. The Effect of Kilovar Supply on the Design of Systems for Load Growth. **T. W. Schroeder, J. W. Butler, N. H. Meyers,** General Electric Company

2:00 p.m. Applications of Electrical Measurements and Basic Sciences

44-55. The Accuracy of Measurements in Lumped *R-C* Cable Circuits as Used in the Study of Transient Heat Flow. **Victor Paschkis, Michael P. Heisler,** Columbia University

44-9. Polarized Light Servosystem. **T. M. Berry,** General Electric Company

44-16. A New Differential Analyzer. **H. P. Kuehni, H. A. Peterson,** General Electric Company

44-24. Symmetrical-Components Analysis of the Four-Phase System. **A. Boyajian,** General Electric Company

44-45. Some Aspects of Inductance When Iron Is Present. **L. T. Rader, E. C. Litscher,** General Electric Company

2:00 p.m. Conference on Marine Transportation

Tuesday, January 25

9:30 a.m. Transmission and Protective Devices

44-13. Transmission and Relaying Problems on the Fort Peck Project. **Erik Floor,** Harza Engineering Company; **H. N. Muller, S. L. Goldsborough,** Westinghouse Electric and Manufacturing Company

44-52. Fusing Practices on Distribution Systems. **John S. Parsons, J. M. Wallace,** Westinghouse Electric and Manufacturing Company

44-30. Reclosing of Single Tie Lines Between Systems. **W. W. Parker, H. A. Travers,** Westinghouse Electric and Manufacturing Company

44-50. An Eight-Year Investigation of Lightning Currents and Preventive-Lightning Protection on a Transmission System. **E. Hansson, S. K. Waldorf,** Pennsylvania Water and Power Company

9:30 a.m. Conference on Turbogenerator Characteristics

This conference is sponsored by the committee on power generation and the Standards committee to develop information that is required in the standardization of turbogenerator characteristics. This is being carried on by the AIEE–ASME Joint Committee on Turbogenerators. The committee is concerned with units of 10,000-kw capacity and above but at present is confining its work to 3,600-rpm units for which the ASME group has recommended 12,500, 20,000, 30,000, 40,000, and 60,000-kw ratings. The conference will include results of a survey of present-day practice in loading and the power-factor rating of generators and also the effect of changing of generator characteristics, such a power-factor rating, short-circuit ratio, temperature rise, on the weight of active material required in the generators. While a part of the conference material will be presented by the AIEE group of the turbogenerator committee, a major portion of the conferene time will be available for general discussion, and it is hoped that as many members will participate as possible.

9:30 p.m. Conference on Measurement of Temperature Rise in Continuous-Duty Machines

2:00 p.m. Circuit Breakers

44-44. The Geometry of Arc Interruption—II. Current Zero Phenomena. **E. W. Boehne,** General Electric Company

44-56. A 500,000-Kva 7.5-Kv Air Circuit Breaker for Steel-Mill Service. **R. C. Dickinson,** Westinghouse Electric and Manufacturing Company

44-37. High-Voltage Oil Circuit Breakers for Rapid Reclosing Duty. **A. W. Hill, W. M. Leeds,** Westinghouse Electric and Manufacturing Company

44-47. A Magnetic-Type Air Circuit Breaker for 15,000-Volt Services. **L. J. Linde, B. W. Wyman,** General Electric Company

44-48. A New Three-Element Current-Limiting Power Fuse. **H. L. Rawlins, H. H. Fahnoe,** Westinghouse Electric and Manufacturing Company

2:00 p.m. Land Transportation

44-20. Electrification of Large Open-Pit Copper Mines. **L. W. Birch,** Ohio Brass Company

44-28. Modern Electric Locomotives in Open-Pit Mine Haulage. **J. E. Borland, L. G. Riley,** Westinghouse Electric and Manufacturing Company

"Open-Pit Copper Mining," a motion picture, by courtesy of the General Electric Company

44-25. Design Features of Generators for Diesel-Electric Switcher Locomotives. **C. A. Atwell,** Westinghouse Electric and Manufacturing Company

44-27. Diesel-Electric Switching-Locomotive Application by Means of Nomographic Charts. **A. P. Millan, T. F. Perkinson,** General Electric Company

44-26. Gear Ratio and Its Effect on Traction Motors. **G. M. Woods,** Westinghouse Electric and Manufacturing Company

2:00 p.m. Conference on Permissible Temperature Rise of Short-Time Rated Machines

2:00 p.m. Conference on Speed Relaying

CP.* Effect of Relaying Time on Damage to Equipment and Lines. **H. R. Paxson,** Philadelphia Electric Company

CP.* Effect of Speed of Relaying on System Stability. **R. C. R. Schulze,** Public Service Electric and Gas Company

CP.* Influence of High-Speed Relaying and Reclosing on Over-All System Performance. **C. E. Parks,** Public Service Company of Indiana

6:30 p.m. Smoker at the Hotel Commodore

Wednesday, January 26

10:00 a.m. General Session

Presentation of Edison Medal to Vannevar Bush

Feature talk on a timely topic to be of interest to many members

2:00 p.m. Conference on Lighting

Address: "Progress in Lighting." **Preston S. Millar,** Electrical Testing Laboratories

Address: "Seeing Things," illustrated by motion pictures. **S. G. Hibben,** Westinghouse Electric and Manufacturing Company

2:00 p.m. Relays

44-46. The MHO-Carrier Relaying Scheme. **R. E. Cordray, A. R. vanC. Warrington,** General Electric Company

44-51. The Functions of Ground Preference in Carrier-Current Relay Schemes. **S. C. Leyland, S. L. Goldsborough,** Westinghouse Electric and Manufacturing Company

44-68. System Voltages and Fault Currents Determined Easily on D-C Board. **C. E. Asbury,** Illinois Iowa Power Company

44-34. A Versatile Power-Line Carrier System. **H. W. Lensner, J. B. Singel,** Westinghouse Electric and Manufacturing Company

2:00 p.m. Conference on Industrial Control

44-18. Inverter Action on Reversing of Thyratron Motor Control. **H. L. Palmer, H. H. Leigh,** General Electric Company

2:00 p.m. Conference on Civic Affairs and Co-operation with Other Organizations

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*CP: Conference paper; no advance copies are available; not intended for publication in *Transactions*.

Tentative National Technical Meeting Program (Continued)

2:00 p.m. Meeting of Safety Committee

44-22. Study of Artificial Respiration on Anesthetized Men. **W. B. Kouwenhoven, D. R. Hooker, J. A. York,** The Johns Hopkins University

Thursday, January 27

9:30 a.m. Air Transportation

44-32. Present D-C Aircraft Electric-Supply Systems. **H. C. Anderson, Jr., S. B. Crary, N. R. Schultz,** General Electric Company

44-38. Electric-Circuit Fault-Protective Principles as Applied to D-C Aircraft Systems, **R. H. Kaufmann,** General Electric Company

44-36. Basic Considerations in Selection of Electric Systems for Large Aircraft. **W. K. Boice, L. G. Levoy, Jr.,** General Electric Company

44-43. Testing Aircraft Generators. **H. E. Keneipp,** Westinghouse Electric and Manufacturing Company

44-7. Electric Circuits and the Magnetic Compass. **R. C. Burt, H. R. Beck,** Lockheed Aircraft Corporation. Presentation by title

9:30 a.m. Conference on Domestic and Commercial Applications

44-69. The Vibration of Electrical Contacts. **M. N. Russell, Saul Keilien,** Pass and Seymour, Inc. 15 cents by mail.

CP.* Design Procedure for Low-Temperature Panel-Space Heating. **B. F. Raber, F. W. Hutchinson,** University of California

CP.* Data on Electric Loads of Wartime Projects. **O. B. Falls, Jr.,** General Electric Company

CP.* Resistance Wire. **W. A. Gatwood,** Hoskins Manufacturing Company

CP.* Low-Reactance Busway. **J. G. Jackson,** Square D Company

CP.* Protective Devices. **Stephen Jones,** Heinemann Circuit-Breaker Company

9:30 a.m. Conference on Industrial Power Applications

44-18. Inverter Action on Reversing of Thyratron Motor Control. **H. L. Palmer, H. H. Leigh,** General Electric Company

CP.* Experience With Short Circuits and Breakers, With Emphasis on Co-ordination Between Fuses and Breakers. **L. C. Peterman,** Ford, Bacon, and Davis

CP.* Lightning Protection for Industrial Equipment Operating at Line Potential. **A. C. Muir,** Berwind-White Coal Mining Company

CP.* Plant Distribution Systems. **C. E. Smith,** New York Shipbuilding Corporation

CP.* Dodge Chicago Plant's Distribution Scheme With Airplane-Engine Power-Recovery Circuits. **E. L. Bailey,** Chrysler Corporation

CP.* Induction-Heating Application. **H. E. Somes,** Budd Induction Heating, Inc.

2:00 p.m. Air Transportation

44-57. Effect of Altitude on Electric Breakdown and Flashover of Aircraft Insulation. **L. J. Berberich, G. L. Moses, A. M. Stiles, C. G. Veinott,** Westinghouse Electric and Manufacturing Company

44-58. Electric-Circuit Burning-Clear and Damage Phenomena on Aircraft Structures. **C. M. Foust, J. G. Hutton,** General Electric Company

44-29. Potential Breakdown of Small Gaps Under Simulated High-Altitude Conditions. **M. J. DeLerno,** General Electric Company

44-59. Corona in Aircraft Electric Systems as a Function of Altitude. **W. R. Wilson,** General Electric Company

44-5. Aircraft Signal Systems. **Raymond A. Rugge,** Curtiss-Wright Corporation

44-70. Electrically Driven Gyroscopes for Aircraft. **H. M. Witherow, Albert Hansen, Jr.,** General Electric Company

2:00 p.m. Communication and Electronics

44-42. Crossbar Toll-Switching System. **L. G. Abraham, A. J. Busch, F. F. Shipley,** Bell Telephone Laboratories, Inc.

44-49. Automatic Ticketing of Telephone Calls. **O. A. Friend,** Bell Telephone Laboratories, Inc.

44-14. A Short-Cut Method of Estimating TIF of Power Systems With Rectifier Load. **C. W. Frick,** General Electric Company

44-41. Rectifier Circuit Duty. **C. C. Herskind,** General Electric Company

44-8. Electronically Controlled Dry-Disk Rectifier. **Allen Rosenstein, H. N. Barnett,** Signal Engineering Products Company

2:00 p.m. Industrial Power Applications

44-19. A New Electric Hoist Drive for Cranes. **M. A. Whiting,** General Electric Company

44-60. Heating of Nonmagnetic Electrical Conductors by Magnetic Induction—Longitudinal Flux. **R. M. Baker,** Westinghouse Electric and Manufacturing Company

44-39. Supervisory Control for the World's Most Modern Steel Mill. **P. B. Garrett, M. E. Reagan,** Westinghouse Electric and Manufacturing Company

44-61. Electrical Equipment for the War-Emergency Pipe-Line Projects. **E. E. Thomas, W. G. Taylor,** General Electric Company; **Oscar Wolfe,** War Emergency Pipelines, Inc.

44-40. The Capacitor—An Aid to Electric-Power Service for Pipe Lines. **M. A. Hyde, R. E. Marbury,** Westinghouse Electric and Manufacturing Company. "Oil for War," a colored motion picture, by courtesy of the Barrett division, Allied Chemical and Dye Corporation

8:00 p.m. Joint IRE-AIEE Session

Address: "Enemy Army Communications Equipment." **Major General Roger B. Colton,** Signal Corps, United States Army. Captured equipment will be on display at the conclusion of the address.

Friday, January 28

9:30 a.m. Electrical Machinery

44-35. The Asymmetrical Stator as a Means of Starting Single-Phase Induction Motors. **John L. Baum,** Chillicothe, Ohio

44-1. Design of Starting Windings for Split-Phase Motors. **T. C. Lloyd,** Robbins and Myers, Inc.; **J. H. Karr,** Purdue University

44-2. Some Aspects of Electric-Motor Design—Polyphase-Induction-Motor Design to Meet Fixed Specifications. **T. C. Lloyd,** Robbins and Myers, Inc.

44-63. A Design Method for D-C Machines. **M. I. Beers,** Robbins and Myers, Inc.; **J. H. Karr,** Purdue University

44-64. Starting Windings for Single-Phase Induction Motors. **C. G. Veinott,** Westinghouse Electric and Manufacturing Company

9:30 a.m. Conference on Automatic Stations

2:00 p.m. Transformers

44-6. Asymmetrical Loading of Three-Phase Three-Winding Transformer Banks. **P. K. Denissov,** Academy of Science of the USSR

44-65. Thermal Protection of Transformers Under Overload Conditions. **V. M. Montsinger, G. Camilli,** General Electric Company

44-66. Overloading of Transformers—Cases Not Covered by the General Rules. **W. C. Sealey, J. B. Hodtum,** Allis-Chalmers Manufacturing Company

44-67. Effect of Altitude on Impulse and 60-Cycle Strength of Electrical Apparatus. **P. L. Bellaschi, Paul Evans, Jr.,** Westinghouse Electric and Manufacturing Company

2:00 p.m. Conference on Administrative Problems in Army and Navy Specialized Training Programs

44-3. Cultural Training of the Engineer. **A. Boyajian,** General Electric Company

8:15 p.m. Teaching Aids for Navy Specialized Training Programs

Address: "Electricity on Shipboard." **Captain H. G. Rickover,** Bureau of Ships, United States Navy

Saturday, January 29

9:30 a.m. Special Lecture at, and Inspection Trip Through, the Brooklyn Navy Yard

Under the direction of Captain H. G. Rickover, and open only to a specially selected and invited teaching personnel from the colleges in which Navy Specialized Training Programs are conducted.

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fee of two dollars will be charged to all nonmembers except Enrolled Students and the immediate families of members.

Hotel reservations should be made by writing directly to the hotel preferred.

COMMITTEE

The personnel of the 1944 winter technical meeting committee, which is making the arrangements, is as follows: J. F. Fairman, *chairman;* W. J. Barrett, F. A. Cowan, J. L. Callahan, M. D. Hooven, C. R. Jones, R. A. Jones, F. V. Magalhaes, C. S. Purnell.

NATIONAL ....

Smaller Trim Size for "Electrical Engineering"

To maintain the technical content of *Electrical Engineering* at a high level and still comply with governmental restrictions on the use of paper, the trim size has been reduced to $8^1/_8$ by $11^1/_4$ inches, effective with this issue. The dimensions of the type page are being maintained essentially as before so that the net result is a more efficient use of paper through reduced page margins. In fact, minor changes were required in the feature-article and news sections to adapt those pages to the new size, which increase the amount of material per page.

The majority of technical society and trade publications adopted this smaller size during 1943 in order to effect the required reduction in paper usage in that year (ten per cent less than in 1942). *Electrical Engineering* could not do this without inconvenience to e *Transactions* subscribers, however, be- use sheets for the annual *Transactions* lumes are printed month by month while e monthly sections are on the press, and if change had been made during the year e result would have been two different- ed pages in the 1943 *Transactions* volume.

In addition to the smaller trim size, hterweight paper for both the text pages d the covers is being used as the present pply becomes exhausted. These two anges will enable *Electrical Engineering* to rry in 1944 practically the same content in 1943, unless further restrictions on the e of paper become necessary later in the ar. Present usage is limited to 75 per nt of the tonnage used in 1942. Whether not a further curtailment will become cessary is said to depend on the results of e present intensive conservation and lvage campaign (see page 34).

IEE Nominating Committee for 1943–44 Announced

The national nominating committee of the IEE, in accordance with the Institute's ylaws, will meet during the winter technical eeting January 24–28, 1944, in New York, . Y., to nominate candidates for national fficers to be voted on by the membership in e spring of 1944. Members of the national ominating committee are as follows:

epresenting the board of directors

M. Laffoon, Westinghouse Electric and Manufac- ring Company, East Pittsburgh, Pa.

G. LeClair, Commonwealth Edison Company, nicago, Ill.

. B. McEachron, General Electric Company, Pitts- ld, Mass.

W. Schilling, Montana State College, Bozeman, ont.

. R. Smith, Public Service Electric and Gas Com- any, Newark, N. J.

lternate:

. S. Osborne, American Telephone and Telegraph ompany, New York, N. Y.

epresenting the ten geographical Districts

Everett S. Lee, General Electric Company, Sche- ectady, N. Y.

R. C. Gorham, University of Pittsburgh, Pittsburgh, a.

C. S. Purnell, Westinghouse Electric and Manufac- ring Company, New York, N. Y.

J. Elmer Housley, Aluminum Company of America, lcoa, Tenn.

J. A. Northcott, Jr., University of Notre Dame, otre Dame, Ind.

Arthur L. Jones, General Electric Company, Denver, olo.

C. H. Kraft, Union Electric Company of Missouri, t. Louis, Mo.

B. L. Robertson, University of California, Berkeley, alif.

Orin A. Demuth, Bonneville Power Administration, ortland, Oreg.

0. A. H. Frampton, Hydro-Electric Power Com- ission of Ontario, Toronto, Ont., Canada

lternates:

J. R. Smith, Louisville Gas & Electric Company, ouisville, Ky.

Lawrence M. Robertson, Public Service Company f Colorado, Denver, Colo.

F. A. Cooper, Southwestern Bell Telephone Com- any, St. Louis, Mo.

DISTRICT • • • • •

Great Lakes District Executive Committee Meets

The executive committee of the Great Lakes District held its annual meeting in Chicago, Ill., November 5, 1943, with 100 per cent representation of Sections. A. G. Dewars (M '27) District vice-president, presided.

M. S. Coover (F '42) professor and head of the department of electrical engineering, Iowa State College, Ames, was nominated for AIEE vice-president to represent the Great Lakes District, and J. A. Northcott, Jr. (M '40) head of the department of electrical engineering, University of Notre Dame, South Bend, Ind., was elected representative on the national nominating committee. N. C. Pearcy (M '30) acting treasurer, was elected District treasurer to succeed K. A. Auty (M '17) who resigned in January.

The meeting was addressed by L. A. Griffith, District vice-chairman of the national membership committee, who reported on the growth of membership in the District and presented curves showing the activities of each Section. The question of local memberships and the difficulty of getting local members to become national members was raised when a decrease in membership was reported for the Milwaukee Section. The Michigan Section stated that limiting local memberships to three years had solved that problem in its group.

It was suggested that each Section investigate the possibilities of subsections, following the lead of the Urbana and Madison Sections in establishing one each. Fargo–Grand Forks and Duluth–Superior were considered as possible subsection groups.

The question of collective bargaining and licensing laws for engineers was discussed at length.* As a result, the following resolution was proposed to be forwarded to AIEE headquarters: "Resolved, that the board of directors be requested to appoint a special committee to investigate encroachment of unionism into the province of engineering as a profession, and to formulate a policy to be followed with respect to collective bargaining, socialization of engineers, and related subjects."

In line with this resolution the executive committee requested that each Section within the District submit a report relative to labor-union encroachments in its area, and that it express an opinion on the resolution adopted.

Also discussed at length were the Kilgore–Patman bills (*EE, August '43, pp. 360–1; 381*) pending in the Senate and House of Representatives, which would pave the way for the socialization of engineers. It was recommended that, even though the Institute had already taken formal action in the matter, the Sections express themselves likewise by a vote of the membership. It was thought that a larger number of individual letters to Senators and Congressmen would exert more pressure than group action.

Professor M. M. Cory (F '40) chairman, District committee on student activities, stated that student memberships had decreased approximately 60 per cent because of enlistment and induction of students in the Armed Forces. In order to keep the Branches active, he recommended joint meetings with branches of the American Society of Civil Engineers, American Society of Mechanical Engineers, and other engineering organizations.

No District technical meeting will be held for 1944–45 because of wartime handicaps and since the 1944 AIEE summer technical meeting will be held relatively close to the Sections of the Great Lakes District.

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*The board of direction of the American Society of Civil Engineers recently took action authorizing the formation of collective bargaining agencies for "professional engineering employees." See item in "Current Interest" section, this issue.

SECTION • • • • •

Use of Magnesium in Planes Topic of Milwaukee Section Meeting

Every American warplane built today utilizes more magnesium than its predecessor model, whereas German planes recently shot down show less magnesium than those shot down earlier in the war, explained Arthur Smith, Jr., of the Dow Chemical Company to over 200 engineers at a Milwaukee AIEE Section meeting recently.

Every cubic mile of sea water has 9,000,000,000 pounds of magnesium in it, and Americans are getting it into planes as fast as they can, with the result that some war planes have as much as half a ton of the metal. With these planes, American and British airmen have been bombing German magnesium plants as fast as they can, said Mr. Smith.

In 1938 production of magnesium was barely 2,000 tons, but the present production is over one hundred times that quantity. In some types of construction the use of magnesium alloys can save from 19 to 33 per cent in weight over aluminum, and so this new metal is used in aircraft and lightweight portable equipment wherever a changeover is possible without slowing production.

Portable tools, reciprocating high-speed machinery, trucks, busses, and airplanes will be the big postwar consumers of magnesium, Smith predicted.

ABSTRACTS • • •

TECHNICAL PAPERS previewed in this section will be presented at the AIEE winter technical meeting, New York, N. Y., January 24–28, 1944, and are expected to be ready for distribution within the current month. Copies may be obtained by mail from the AIEE order department, 33 West 39th Street, New York 18, N. Y., at prices indicated with the abstract; or at five cents less per copy if purchased at AIEE headquarters or at the convention registration desk.

Mail orders will be filled
AS PAMPHLETS BECOME AVAILABLE

Air Transportation

44-29—Potential Breakdown of Small Gaps Under Simulated High-Altitude Conditions; *M. J. DeLerno (A '43). 15 cents.* Because of the variation in air pressure and temperature with altitude, the breakdown-

Future AIEE Meetings

Winter Technical Meeting
New York, N. Y., January 24–28, 1944

North Eastern District Meeting
Boston, Mass., April 1944

Summer Technical Meeting
St. Louis, Mo., June 26–30, 1944

Pacific Coast Technical Meeting
Los Angeles, Calif., Aug. 29–Sept. 1, 1944

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potential characteristics of aircraft electric equipment differ from those of other pieces of industrial electric equipment. This paper shows the effect of altitude on the air-gap breakdown potential between hemispheres and between various current-carrying parts of typical aircraft equipment; the paper also shows the effect of altitude on creepage or surface breakdown for similar specimens. The effects of frequency and humidity on the breakdown characteristics are also investigated. Special considerations which may exist for aircraft electric equipment are taken into account when conclusions concerning the effects of the various factors mentioned are drawn.

44-32—Present D-C Aircraft Electric-Supply System; *H. C. Anderson, Jr. (A '43), S. B. Crary (M '37), N. R. Schultz (A '40). 20 cents.* This paper presents the results of analytical investigations and laboratory and field tests on present 28-volt d-c aircraft electric systems. The paper deals with the performance of the various components of the electric-supply system as well as the operation of the system as a whole. The system problems investigated are: system-voltage accuracy, load division during parallel operation of generators, relay contactor chatter, generator-output capacity, effects of heavy transient loads, and short-circuit currents.

44-36—Basic Considerations in Selection of Electric Systems for Large Aircraft; *W. K. Boice (M '43), L. G. Levoy, Jr. (M '43). 30 cents.* This paper presents some of the considerations involved in selecting electric systems for large aircraft. Such systems now are undergoing intensive development, and, consequently, it is not possible to give complete answers to all problems which arise. Also, certain parts of the electric systems are subject to military classification and cannot be discussed. Nevertheless it is felt that many engineers, particularly those engaged in the design of such systems, will welcome a brief review of the basic factors involved. Industrial and central-station experience provide a valuable background for study of aircraft systems. However, too close an adherence to previous practice should not be maintained since aircraft systems differ in many ways from those of land equipment. The need for minimum weight demands that only those features be included which fundamental considerations show to be necessary or at least provide benefits which justify the weight involved. Hence, a review of the basic problems encountered should be helpful at this time.

44-38—Electric-Circuit Fault-Protective Principles as Applied to D-C Aircraft Systems; *R. H. Kaufmann. 30 cents.* Adequate fault protection assumes ever-increasing importance as the size and responsibility of aircraft electrical systems increase. Increased short-circuit current levels mean greater switching-equipment duty and potential fire hazard. Larger amounts of rotating load machinery introduce a problem of electrical stability and emphasize the need for rapid fault clearing. The purpose of this paper is to outline the characteristics of various applicable fault-detection devices and the manner in which they may be used most effectively in typical aircraft circuits. Important considerations to be recognized in judging the effectiveness of a particular system of fault protection include:

1. Reliability and selectivity—only fault protectors adjacent to an electrical fault can operate and do so reliably.

2. Operating speed—more rapid fault clearing diminishes fire hazard and improves operating stability of the remaining system.

3. Simplicity—simplicity of design, application, installation, and field maintenance are all important.

4. Cost in weight.

44-43—Testing Aircraft Generators; *H. E. Keneipp (A '40). 15 cents.* The modern fighting plane requires a large amount of electric power for its successful operation. The d-c aircraft generator provides a reliable source of power at the lowest possible weight. The development of these generators has required close co-ordination of design, testing, and interpretation of test results. The tests include raw material, laboratory, life, mechanical, and flight tests. Generator parts as well as complete machines are being tested continually. The generator test program has been responsible for the correction of troubles which have developed in the field and also for the elimination of potential sources of trouble. It has also been responsible for improvements in the use of material so that extremely low weight has been obtained. No untried parts or materials can be used in an aircraft generator. Laboratory tests must be relied upon for a preliminary check of all improvements before they are subjected to flight testing.

44-57—Effect of Altitude on Electric Breakdown and Flashover of Aircraft Insulation; *L. J. Berberich (M '36), G. L. Moses (A '43), A. M. Stiles (A '43), C. G. Veinott (M '34). 30 cents.* The breakdown strength of air and the surface flashover behavior of a number of materials have been investigated under conditions corresponding to an altitude range from sea level to 65,000 feet. The various atmospheric conditions encountered by aircraft in this altitude range were simulated by use of a special test chamber. The pressures and temperatures were reproduced as well as the moisture, cloud, ice and snow conditions. Moisture in the condensed droplet form was found to lower both the breakdown strength of air and the flashover voltage of materials. On the other hand, moisture in the frozen form, such as ice, and snow, did not have any marked effect on either the breakdown strength of air or flashover behavior of materials. On the basis of extensive data given in the paper and general experience with various types of electric apparatus, specific striking and creepage or flashover distances have been proposed for aircraft electric equipment in the various voltage classes.

44-58—Electric-Circuit Burning-Clear and Damage Phenomena on Aircraft Structures; *C. M. Foust (M '31), J. G. Hutton. 20 cents.* Normal and continuous performance of electric circuits is a prerequisite to the effective use of airplanes. Electric short circuits, which result in the loss of power for vital control operations, or cause fires, are definite hazards. The extensive use of the 28.5-volt d-c aircraft systems, and the consideration being given a three-phase 208-volt 400-cycle a-c grounded neutral system for high-altitude planes necessitated an investigation into the burning-clear and damage phenomena on both circuits. Short circuits were applied on an aluminum alloy system of an airplane and oscillograms of short-circuit current and voltage taken. In both the a-c and d-c systems it was found that the fault-damage and burning-clear phenomena depended upon the energy level in the short-circuit area. When the contact area between the conductor and aircraft structure was small, the energy level was high and the fault burned itself clear. In such cases the aircraft structure was perforated. Increase in contact area and a consequent reduction in energy concentration resulted in a sustained fault current. In some of these cases a definite welding of the conductor to the aircraft structure occurred, whereas in others no burning took place.

44-59—Corona in Aircraft Electric Systems as a Function of Altitude; *W. R. Wilson. 20 cents.* Corona-starting voltages of the components of a 208-volt 400-cycle grounded-neutral electric system are reported for altitudes between sea level and 50,000 feet. The corona characteristics are shown to be functions of air pressure, electric-field geometry, humidity, and the cleanliness of insulating surfaces. The effect of reducing pressure is shown to lower the corona-starting voltages of aircraft cables by as much as 60 per cent, because the dielectric strength of large air gaps drops a comparable amount. Reducing the pressure has small effect on the corona-starting voltages of low-voltage capacitors, because the dielectric strength of small air gaps is nearly independent of pressure. Moisture and dust on insulating surfaces and moisture in aircraft cables produce coronalike disturbances below 208 volts. Data are presented on cables, capacitors, parallel studs, and needle gaps. Under dry conditions all corona-starting voltages were well above the operating voltage of the system.

Basic Sciences

44-24—Symmetrical-Components Analysis of the Four-Phase System; *A. Boyajian (F '26). 15 cents.* Symmetrical-component concepts are developed for the currents, voltages, and impedances of a four-phase system, and formulas are given for various types of short circuits. The idea of symmetry among the members of each set is based on the angular displacement between the members of the set, rather than on phase rotation, which fits the three-phase case very nicely ut is inadequate for the four-phase case. side from its possible value for four-phase roblems, which are rather rare, the paper is resented here in the expectation of an additional benefit, namely, that the parallelisms nd contrasts between the four-phase and the hree-phase formulas may throw further ght on the general theory and applications f symmetrical components.

4-45—Some Aspects of Inductance When ron Is Present; *L. T. Rader* (*A '34*), *E. C. itscher. 30 cents.* There are three definitions f inductance commonly found in textbooks nd handbooks. These all assume a straightne saturation curve and so yield the same onstant value. This paper attempts to how the errors inherent in such definitions vhen iron is present. Various definitions of nductance are examined in the light of the pplication where the term is used. Comparisons are made of four definitions for diferent flux densities. Consideration is prinarily confined to circuits in which no air ap exists. Oscillograms are given showing he effect of saturation and eddy currents. An analytical expression for the saturation urve of silicon steel is presented by means f which the various definitions could be asily examined analytically. The use of he term inductance is examined in connecion with welding of contactor tips, arc nterruption of motor circuits, current buildp and decay of solid iron fields, and reactor ircuits.

Communication

4-42—Crossbar Toll-Switching System; *. G. Abraham* (*M '39*), *A. J. Busch* (*M '30*), *. F. Shipley* (*application pending*). *25 cents.* A new mechanical toll-switching system developed by the Bell System was placed in service n August 1943 to handle calls originating or erminating in Philadelphia, Pa., or passing hrough it. Connections are established by rossbar switches under direction of common control equipment called senders and markers. For the greater part of the calls passing hrough the new toll office, no operating labor s required within the office itself. Some of the ncoming trunks, however, are not arranged or dial operation, and calls coming in over hese trunks are handled by operators at ordless positions equipped with key sets. Connections are made on a four-wire basis; hat is, separate transmission paths are provided for the two directions of talking, and epeaters are switched in automatically when equired. Compared with manual switching, the new system offers substantial improvements in quality and speed of toll ervice.

4-49—Automatic Ticketing of Telephone Calls; *O. A. Friend* (*M '31*). *25 cents.* There s being placed in commercial service by the Bell System in a suburb of Los Angeles a ew arrangement of dial central-office witching equipment designed to enable subscribers to dial their own calls to other points n the metropolitan area without help of an perator, and thereby obtain the speed and onvenience of direct dial service. The quipment automatically prepares a printed icket showing the calling and called numbers and other information needed for harging for the call. The system is designed for application to areas employing central-office switching equipment of the step-by-step type and provides trunking features designed for efficient use of interoffice trunk plant in such metropolitan networks.

Electric Machinery

44-35—The Asymmetrical Stator as a Means of Starting Single-Phase Induction Motors; *J. L. Baum. 25 cents.* A single-phase induction motor with but one winding will have starting torque if the stator is not symmetric with respect to the center of each pole. This paper presents a mathematical analysis of this type of motor, deriving formulas to predict the performance and determine the effect of various details of design. Emphasis is placed upon the motor using a varying air gap. Sample calculations are included.

44-63—A Design Method for D-C Machines; *M. I. Beers* (*A '43*), *J. H. Karr* (*A '32*). *20 cents.* The design engineer is often confronted with the problem of making use of standard mechanical parts from which the required motor performance is obtained by properly proportioning of the armature and field windings. The method of machine design presented herein utilizes the full-load performance requirements from which the windings can be determined directly. The procedure does not present any new fundamental theory, but rather a difference in design approach, or viewpoint. The method is illustrated by the use of a numerical example showing a typical design of a d-c series motor and the test results of the particular design.

44-64—Starting Winding for Single-Phase Induction Motors; *C. G. Veinott* (*M '34*). *30 cents.* Methods are given to enable the design engineer to determine the best starting winding and the best capacitor, reactor, or resistor required to meet any specified requirements. The methods given have been in actual use by design engineers for over 12 years and are as useful today as they were when developed. Simple circle diagrams depict graphically the principles involved in the method. Some practical observations, based on experience, are given. A calculation form, with sample calculations, is also included.

44-65—Thermal Protection of Transformers Under Overload Conditions; *V. M. Montsinger* (*F '29*), *G. Camilli* (*F '43*). *20 cents.* Overloads in close agreement with the emergency overloads recommended both by the AIEE and American Standards Association (Test Code C-57.3) now can be obtained by the use of a relay controlled by a specially designed heating coil, the time constant of which is large in comparison with that of the winding. Similar results also can be obtained by the use of a heating coil, the time constant of which is about the same as that of the winding, for operating a relay that is compensated for changes in ambient temperature. A thermal protective system has been developed which will perform three separate functions: control fans, give a warning signal, and sound an alarm or if desired trip the transformer off the circuit. A diagrammatic sketch and photographic prints show the various combinations of bulbs and relays available. It is believed that the system allows transformers to be loaded more nearly in agreement with the recommended industry loadings than any previous available device.

44-66—Overloading of Transformers—Cases Not Covered by the General Rules; *W. C. Sealey* (*M '38*), *J. B. Hodtum* (*A '26*). *15 cents.* The general relations covering the heating of transformers and the effects of this heating on safe overloads are simple in principle, but the mathematics involved are complex. When suitable curves are used to express the relations, the simplicity is evident. Loading of transformers and other equipment by temperature is increasingly common and rightly so. An understanding of the principles involved aids in intelligent application of information for loading by temperature. The usefulness of the American Standard Guide for Operation of Transformers would be increased by the inclusion of temperature time charts so that a solution may be obtained for the unusual loading case. These charts are based on the same principles on which the present rules are based. In addition to simplifying the procedure for taking care of special cases, such charts present a graphic picture of the heating relations of transformers.

44-67—Effect of Altitude on Impulse and 60-Cycle Strength of Electrical Apparatus; *P. L. Bellaschi* (*F '40*), *P. Evans, Jr.* (*A '38*). *20 cents.* Altitude is accompanied by a lowering of the air density (*RAD*) and affects dielectric strength and thermal and other performance of electrical apparatus. Much research has been directed to these problems, but certain fundamental data are still lacking. The impulse and 60-cycle data in this paper should therefore be timely. The apparatus tested covers line and station insulators, bushings, wood crossarms and rod gaps; indoor apparatus; also insulation of engineering interest. The air strength of apparatus to $1^1/_2 \times 40$-microsecond waves can be considered proportional to *RAD*. Sixty-cycle strength and corona are similarly affected. *RAD* corrections for front-of-wave impulse are less. The oil strength of apparatus is practically unaffected. Humidity and other effects are influencing factors. Rating of apparatus for high altitude should recognize these facts.

Electronics

44-41—Rectifier Circuit Duty; *C. C. Herskind* (*M '40*). *20 cents.* The design and application of rectifiers may be considerably simplified and facilitated by defining the action in terms of:

1. The circuit duty imposed on the rectifiers by the current and voltage waves.
2. The rectifier capacity as measured in terms of the maximum circuit duty at which it is capable of operating successfully.

The circuit duty is determined by the constants of the a-c and d-c circuit, inasmuch as the function of the rectifying element is essentially that of a switch. With a knowledge of the circuit duty of the various rectifier circuits, a given rectifying element may be used in new applications with full assurance if its capacity is known. This paper discusses eight specific factors which together define the circuit duty imposed on the rectifier. Various rectifier circuits are analyzed to show the functional relationship between these factors which define circuit duty and the circuit constants. The definition of circuit duty is essential to the engineer in the determination of the required rectifier capacity and the prediction of performance. The effect of phase control upon the circuit duty imposed on the rectifier is discussed. The factors relating circuit arrangement to the duty under fault conditions also are considered. A classification of the more common rectifier circuits on the basis of circuit duty is presented, and some of the factors entering into the choice of circuit for particular applications are discussed.

Industrial Power Applications

44-39—Supervisory Control for the World's Most Modern Steel Mill; *P. B. Garrett (M '30), M. E. Reagan (F '41). 15 cents.* Although supervisory-control systems have been used previously to control the over-all main power supplies for steel mills, they have, for the first time, been applied to the entire electric-circuit control of a large installation. The chief advantages are to bring the control and supervision of all electric circuits to one central location where the dispatcher has, at all times, a complete, accurate survey of all the generating, and transmission and distribution circuits and to conserve vital war materials in the over-all construction program. The motor-room equipments are unattended, the starting and stopping operations being performed by the power dispatcher in a minimum of time. Power outages are quickly located and restored.

44-40—The Capacitor—An Aid to Electric-Power Service for Pipe Lines; *M. A. Hyde, Jr. (A '27), R. E. Marbury (M '36). 25 cents.* In the over-all design of an electrified oil pipe line, power service constitutes a major problem, not only because of its importance in the economic structure, but also because it is a problem more varied in its component parts than almost any other phase of the project. Station designs are for the most part repetitive; power-service facilities up to the point of delivery vary widely from station to station. In the completion of three recent major pipe-line projects, power service has been facilitated in numerous instances by capacitors. In some cases, under conditions imposed by war time conservation of power-service materials, capacitors have been the key to successful station operation.

44-60—Heating of Nonmagnetic Electrical Conductors by Magnetic Induction—Longitudinal Flux; *R. M. Baker (M '40). 30 cents.* Most induction-heating problems for the sake of calculation can be resolved into the problem of heating a cylinder, a flat slab, the surface of a slab by a current-carrying conductor near the surface, or some combination of these. This paper outlines the method and gives the necessary equations for calculating these three cases for nonmagnetic materials.

44-61—Electrical Equipment for the War Emergency Pipe-Line Projects; *E. E. Thomas (M '29), W. G. Taylor, Oscar Wolfe. 25 cents.* The 24-inch and 20-inch electrically operated record-breaking oil and gasoline pipe lines extend across the country from Texas to the Atlantic Coast. This paper describes the projects, typical pumping-station equipment and methods of control, including an explanation of the automatic operating and protective features provided on the 20-inch pipe line. Discussions are given of the problems encountered in providing adequate single-phase protection, and in applying capacitors to improve unfavorable power conditions. Data are included to show engineering results obtained in applying power equipment under emergency war conditions.

Instruments and Measurements

44-21—A Multiplied-Deflection A-C Potentiometer; *R. B. Marshall (A '40). 15 cents.* Several types of a-c potentiometers have been developed in past years, but each has been too complicated for common all-purpose usage. This paper describes a potentiometer that is unusually easy to operate and has many ranges. It is portable and suitable for field measurements at power frequencies. No effort was made to reduce the size and weight of the model described, but there is little doubt that it could be arranged as a very compact instrument with self-contained indicating instruments. Since the instrument is based on a null balance, it should be classified as a potentiometer. From another point of view it is an indicating-instrument range extender for the results are obtained by observing the deflections of indicating instruments. Volts or millivolts are observed on a 150-volt voltmeter and amperes or milliamperes are indicated on a five-ampere ammeter. Watts or milliwatt are indicated by a 500-watt wattmeter. Impedances as low as a small fraction of an ohm, and as high as thousands of megohms can be measured readily and their power factors determined.

44-33—Crossed-Coil Power-Factor Meters; *N. P. Millar (application pending). 25 cents.* The increased demand for the measurement of power factor on single-phase and polyphase circuits has made it necessary to design instruments with a large number of scale ranges. Application of an instrument to a specified circuit condition and the scale range determine the scale distribution. The factors which control the scale distribution in the single-phase, three-wire two-phase, three-wire three-phase, and four-wire three-phase crossed-coil type of power-factor meter are shown from the respective fundamental relations. Although limitations on the scale range and distribution necessarily are imposed by mechanical design, a graph of either the equilibrium expressions or the torque of equations emphasizes the theoretical possibilities of scale ranges. These graphs aid materially in the selection of the proper scale range for a given scale angle of deflection.

44-31—Influence of Improved Magnetic Alloys on Design Trends of Electrical Instruments; *M. S. Wilson (M '43), J. M. Whittenton (A '37). 15 cents.* This paper reviews briefly the magnetic alloys which have been utilized previously as magnets in d-c permanent-magnet moving-coil small-panel indicating instruments and describes the properties of a new cobalt–molybdenum–iron alloy which has definite advantages as a permanent magnet in electrical instruments because of its high magnetic strength and good machining qualities. The utilization of this new cobalt–molybdenum–iron alloy for the first time as a permanent magnet in an indicating instrument is described and illustrated. Comparison with a similar instrument having a magnet made of chrome steel demonstrates the improvement in over-all performance and reliability of a given rated instrument using this new magnetic alloy. Particular emphasis is given to the increased "mechanical factor of merit" which is a measure of instrument reliability and other improvements which result from the use of this material.

44-55—The Accuracy of Measurements in Lumped R-C Cable Circuits as Used in the Study of Transient Heat Flow; *Victor Paschkis, M. P. Heisler. 20 cents.* Lumped resistance–capacitance circuits can be conveniently used for the investigation of transient-heat-flow problems. For this purpose a complete network, known as heat and mass-flow analyzer has been erected at Columbia University. This paper deals mainly with the various factors influencing the accuracy of the method. Specifically, the selection of the best number of lumps is analyzed. Two factors cause errors in the current and voltage readings: leakage in capacitors and insulation, and replacement of the "theoretical circuit" with evenly distributed properties (infinite number of lumps) by a circuit with finite number of lumps. From the viewpoint of leakage a small number of lumps is desirable; but from the viewpoint of replacing theoretical current by a lumped circuit a large number of lumps yields better results. Numerical values for the expected error resulting with various numbers of lumps are given. Final recommendations as to best practical lumping are made.

Land Transportation

44-20—Electrification of Large Open-Pit Copper Mines; *L. W. Birch (M '29). 15 cents.* The transportation problem of a large strip mine involves the loading, hauling, and dumping of both ore and waste. These materials are loaded with large electric shovels operating on benches along the slope of a hill or pit. The ore is transported over main-line tracks to the reduction plant while the waste is hauled to suitable dumps. All main-line tracks are permanent and are equipped with permanent overhead distribution systems. All bench and dump tracks are portable and are equipped with portable overhead distribution systems. Sixty per cent of the world's copper is now obtained by open-pit mining of low-grade ore. Electrification of haulage ways for open-pit mining is keeping pace with the expansion and is modernizing the transportation of huge tonnages. Huge capacities necessitating heavy cars, and heavy grades demanding short-period overloads have been responsible for selecting the electric locomotive for motive power. From the standpoint of locomotive

pacity, rail size, dump-car capacity, and
nsity of traffic, most open-pit electrifica-
ons compare in size with our large steam-
ad installations and hold an important
ace in the field of heavy traction. In addi-
on to describing the haulage problem of
rge open-pit copper mines, this paper dis-
isses the design of permanent and portable
stribution systems.

**4-25—Design Features of Generators for
iesel-Electric Switcher Locomotives;** *C. A.
twell (M '43). 15 cents.* The present unparal-
d demand for movement of raw materials
nd finished products is demonstrating the
onvenience and effectiveness of the Diesel-
ectric switcher locomotive. This paper re-
ews both mechanical and electrical features
f generators recently developed for use on
e medium and smaller sizes of switcher loco-
otives. Mechanical features refer espe-
ally to mounting the generators and connect-
ng them to the Diesel engine. Electrical
erformance both as power generators and
s engine-starting motors are discussed, as
ell as the means for obtaining this per-
rmance simply and reliably.

**4-26—Gear Ratio and Its Effect on Trac-
on Motors;** *G. M. Woods (M '43). 15
nts.* The power of practically all traction
otors is transmitted to the vehicle's axles
y means of gears. Developments in gear
esign, gear materials, and heat treatments
ave permitted progressively greater gear
eductions and, hence, the economical use of
igher-speed motors. Higher speed results
n less motor weight and space requirements.
resent-day traction motors weigh only $^1/_5$
s much as motors of similar capacity con-
tructed 40 years ago. This reduction in
ize and weight has made possible the con-
truction of vehicles which afford a superior
ervice to the public and are economical in
peration. In frequent-stop city service
ower gear reduction on a specific motor re-
ults in slightly higher schedule speed with
elatively great increase in energy consump-
ion and motor-heating current.

**4-27—Diesel-Electric Switching-Locomo-
ive Application by Means of Nomographic
Charts;** *A. P. Millan, T. F. Perkinson. 15
nts.* The application of switching loco-
otives involves calculations of locomotive
erformance under given conditions of grade,
rain weight, and length of run. Such cal-
ulations can be made quickly by nomo-
raphic charts. Equipment-heating limita-
ions on Diesel-electric and electric loco-
otives can also be checked by elements
dded to the nomograms. The theory and
he method of construction of such charts
re described in this paper.

**4-28—Modern Electric Locomotives in
pen-Pit Mine Haulage;** *J. E. Borland,
. G. Riley. 15 cents.* For the economical
aulage of large daily tonnages of ore and
aste rock at the Morenci Mine of Phelps
odge Corporation, electric locomotives
ere selected. There are now in use 16
25-ton 750-volt d-c trolley locomotives,
specially designed for open-pit haulage
ervice. These units are equipped with 500-
mpere-hour 500-volt storage batteries for
rain movements on mining benches and
ther unelectrified temporary tracks. The
comotives also provide dynamic braking
to assist in retarding loaded trains descending heavy grades. A number of 125-ton Diesel-electric locomotives are used also in limited waste haulage and miscellaneous duty.

Power Generation

44-30—Reclosing of Single Tie Lines Between Systems; *W. W. Parker (M '37), H. A. Travers (A '41). 15 cents.* This paper presents practical information for guiding the application of high-speed reclosing of single tie-line interconnections following a fault. The system performance during a reclosing cycle is analyzed, and the factors affecting the choice of switching and control equipment are discussed. The relative merits of three-pole (gang-operated) and single-pole (individually operated) breakers are compared for a large number of typical cases in the form of curves plotted between the power transmitted to the receiver system and the electrical length of the line. These curves show that single-pole switching in many cases offers a marked advantage over three-pole switching from the standpoint of transient stability based on two wire to ground faults. Furthermore, additional advantages of single-pole switching occur because the majority of faults are single line to ground. The reduced voltage dips and decreased system oscillations with single-pole switching of such faults are also illustrated.

Power Systems Application of Carrier Current

44-34—A Versatile Power-Line Carrier System; *H. W. Lensner (A '43), J. B. Singel. 15 cents.* In recent years power-line carrier has been used for a number of functions in addition to relaying, such as telemetering, load control, and remote tripping. Any one function can be added to a carrier-relaying system merely by keying the transmitter. However, present-day installations often require that several quantities be transmitted over a single carrier channel simultaneously. In order to accomplish this, audio tones are added to the transmitter and tone filters to the receiver, each tone effectively providing an additional channel. A band-elimination filter is used to allow voice communication between stations without interfering with the tones. To perform these functions and meet different line-tuning problems, unit-type equipment for indoor or outdoor use which is readily adaptable to the requirements of specific installations has been developed. Each unit performs a basic function, and suitable combinations of units allow a variety of applications.

Power Transmission and Distribution

44-23—The Effect of Kilovar Supply on the Design of Systems for Load Growth; *T. W. Schroeder (A '37), J. W. Butler (M '38), N. H. Meyers (A '41). 15 cents.* The benefits that can be obtained by the use of shunt capacitors in electric power systems have been discussed many times in technical literature. The shunt capacitor ability to improve voltage and load power factor, thereby reducing losses, releasing circuit capacity, and postponing the need for additional circuit capacity, has been employed many times where economic considerations have justified such use. Again, other discussions have shown that the greatest use of a given system investment may be had when the basic load kilovar requirements are supplied near the load by either capacitors or condensers. It is the purpose of the present paper to give some indication of the economics and the benefits to be gained from an over-all-system basis, by including the capacitor located, in general, near the load, in the system plans for load growth—thus combining the two major foregoing thoughts. A synthetic but somewhat typical system with steam and hydroelectric generation and industrial, commercial, and domestic loads was taken as the guinea pig. Operating conditions prevailing for present loads and future loads of approximately 165 per cent were studied. Alternative methods of taking care of the load growth and maintaining the same service requirements were compared from the operating and investment angles.

44-50—An Eight-Year Investigation of Lightning Currents and Preventive-Lightning Protection on a Transmission System; *E. Hansson (M '35), S. K. Waldorf (M '36). 25 cents.* The paper presents a detailed analysis of surge-crest ammeter records collected on 308 miles of line. The distribution of strokes by years and by location has been reduced to numbers and found to be random. The protective value of different arrangements of counterpoise are compared, and the effects of bonding adjacent structures on line performance are shown. Evidence is presented which indicates that the surge impedance of conductors on transmission lines is less than 235 ohms. The data have been arranged with a view to using it for the predetermination of line performance from short-term records. Examples of such estimates are given and compared with actual experience. The frequency and magnitude of discharges through lightning arresters connected to well-protected lines are given.

44-52—Fusing Practices on Distribution Systems; *J. S. Parsons (A '27), J. M. Wallace (A '41). 15 cents.* Data on the fusing of primary feeders and distribution transformers have been collected from more than 150 power companies. The paper presents an analysis and discussion of fusing practices based on these data and gives a summary of the data collected.

44-53—Current Rating of Cables as Affected by Mutual Heating in Air or Conduit; *Committee on Research, Insulated Power Cable Engineers Association. 30 cents.* Cables installed in a group in air, either in conduit or without conduit, can carry less current than a single isolated cable because of mutual heating from other cables in the group. This effect has been recognized, but no reliable data are available as to the magnitude of this effect. The Insulated Power Cable Engineers Association sponsored the series of tests reported in this paper to determine the correction factors which should be applied to the allowable loading of a single conduit to obtain the permissible loading for each conduit when installed in a group. Various groupings of conduits were tested as well as groups having different numbers of conduits. From the data obtained a table of correction factors was determined. It is shown that these factors are independent of the type cable, kind of insulation, and the number of conductors per conduit, so that a single table may be used for all cables in conduits. Similarly, a second table gives the correction factors for groups of cables in air without conduit. This table is also independent of the type cable, kind of insulation, and the number of conductors in the cable.

44-54—Calculation of Unbalanced Voltage Drops in Distribution Circuits With Particular Reference to Multigrounded Neutrals; *W. R. Bullard (M '26), H. L. Lowe (M '38), H. W. Wahlquist (M '36). 15 cents.* Basic vector relations underlying a simplified method of calculating unbalanced voltage drops in distribution circuits are presented. The method is applicable particularly to circuits in which phase-to-neutral mutual impedances differ materially from phase-to-phase mutual impedances, but in which individual impedances within each of the two groups do not differ greatly from each other. Most circuits having multigrounded neutrals are of this general type. The method provides for the combination of self- and mutual impedances in such a manner that calculation of voltage drops is reduced basically to a single vector multiplication of a current and an impedance for each phase conductor and for the earth-neutral combination treated as a single return conductor. In practice, the calculation of approximate voltage changes due to unbalanced loads is reduced to a simple algebraic process. Examples of practical working formulas and corresponding impedance data are given.

44-62—Costs Study of 69- to 345-Kv Overhead Power-Transmission Systems; *J. G. Holm (M '29). 30 cents.* Capital and annual costs are determined for a number of power-transmission systems. The systems transmit up to 800,000 kw over distances up to 500 miles at voltages ranging between 69 and 345 kv. System costs are those which existed immediately preceding the current war and are based on data obtained from manufacturers of electric equipment as well as on actual data on a number of existing systems. Systems are equipped with devices for stability improvement. The results show that there is an economic relationship among the transmission voltage, the block of power transmitted, and the transmission distance. Expenditures for devices for increasing the system-stability limit have proved to be amply justified. A kilowatt-mileage region is outlined for which the transmission with 345 kv is more economical than with 230 kv. Curves are given from which costs of various power-transmission systems may be estimated. Costs are represented on a percentage basis in such a fashion that system costs may be easily evaluated at prices other than those taken in the study.

Protective Devices

44-37—High-Voltage Oil Circuit Breakers for Rapid Reclosing Duty; *A. W. Hill (M '41), W. M. Leeds (M '38). 20 cents.* Experience has shown that high-speed reclosing of circuit breakers on transmission lines at voltages up to 132 kv can be of considerable value in maintaining system stability and continuity of service. This paper describes a new line of outdoor oil circuit breakers and the special design features making them suitable for 20- and 35-cycle reclosing duty at voltages as high as 230 kv. Data are included showing high-power laboratory short-circuit tests on these duty cycles at 138 kv and 230 kv at currents corresponding to three-phase duty of more than 2,500,000 kva.

44-44—The Geometry of Arc Interruption—II. Current Zero Phenomena; *E. W. Boehne (F '43). 30 cents.* The manner in which the current is modified in the region of the current zero at which interruption takes place may enhance or jeopardize the circuit interruption. An abrupt interruption of current may produce lower or higher recovery rates, with either accompanied by higher transient recovery voltages. The advent of the modern air circuit breaker is recapitulating the early advances with oil. It has widened the practical possibilities of controlling the current-zero phenomena. Breakers are now available which, instead of producing an abrupt interruption near current zero, permit the current to be deflected in such a manner as to arrive at zero current at a time later than indicated by the normal path of the current. Since the rate of rise of recovery voltage is dependent upon the rate of decay of current, these factors are important to circuit-breaker performance. These phenomena are presented in a descriptive manner, which is backed up with a rigorous mathematical analysis which outlines in equation and curve form, the complete evolution of the recovery voltage characteristic as the current is modified from one extreme to the other. Oscillographic verification of the various recovery voltage phenomena are presented. The phenomena of damping take on a new aspect. The analysis, in effect, adds a new dimension to the rigorous treatment of circuit interruption and comes closer than previous simplifying assumptions to explaining the true nature of circuit performance during the period of current interruption. An attempt is made to exhibit this three-dimensional analysis graphically in such a way as to impart a broader insight into the handiwork of Mother Nature in one of her more legerdemainic moments.

44-46—The MHO-Carrier Relaying Scheme; *R. E. Cordray (M '43), A. R. van C. Warrington (A '31). 25 cents.* Present-day distance and carrier relays are limited by the amount of power-swing current that they can allow to flow in a protected section of line without tripping. The longer the line, the less the power-swing current permissible, because distinction between swings and faults is not possible when the impedance seen by the relays for fault and normal conditions approaches the same magnitude. The method of plotting power-swing loci and relay characteristics on the same impedance diagram has facilitated the design of relays to trip not only on faults but on unstable load conditions, and to refrain from tripping on loads and power swings from which the system is considered likely to recover. The new relays measure admittance and are called mho units. A distance-carrier relay scheme has been based on these mho units which is very much simpler than the present distance-carrier relay circuits.

44-47—A Magnetic-Type Air Circuit Breaker for 15,000-Volt Services; *L. J. Linde (A '39), B. W. Wyman (A '40). 15 cents.* This paper describes the development of a magnetic air circuit breaker of the Magne-Blast type for 15,000-volt services with an interrupting capacity of 250,000 kva. Magne-Blast circuit breakers previously developed for lower voltages demonstrated the effectiveness of rapidly increasing the electric resistance of the arc prior to interruption, both in reducing the short-circuit current and in reducing the rate of rise and magnitude of the recovery voltage. As the circuit voltage is increased, the arc resistance must be increased proportionally to obtain the same percentage reduction in current and rate of rise of recovery voltage. The higher arc resistance necessary for 15 kv is obtained by increasing the thermal efficiency of the interleaving arc chute. This arc chute is discussed in detail. Design features of the breaker are described, as well as its application to metal-clad switchgear. Complete test data and representative oscillograms are included to substantiate the interrupting rating assigned to this breaker.

44-48—A New Three-Element Current-Limiting Power Fuse; *H. L. Rawlins (M '41), H. H. Fahnoe (A '35). 15 cents.* The reliable performance of the three-element current-limiting fuse in protecting potential transformers and small auxiliary power transformers has created a demand for higher-current ratings. Therefore, a new three-element current-limiting fuse with a continuous rating of 200 amperes has been developed for protection of motor starters at 2,500 and 5,000 volts and in ratings through 100 amperes at higher voltages to permit tapping small blocks of power from high-capacity systems. A description is given of the new three-element current-limiting fuse which utilizes a novel form of fusible element to combine high continuous current capacity in a small single-cartridge fuse with extremely fast melting on high values of short-circuit current. Data and oscillograms presented cover high-power laboratory tests which show that the full range of fault currents was interrupted without producing voltage surges in excess of 160 per cent of normal system peak voltage.

44-51—The Functions of Ground Preference in Carrier-Current Relay Schemes; *S. C. Leyland (M '43), S. L. Goldsborough (M '43). 15 cents.* All of the more common present-day carrier-current relay systems employ a feature known as "ground preference" which insures that, during faults involving ground current, the ground relays supersede the phase relays in controlling the carrier and tripping functions. In general, the reasons for this arrangement are not well understood and it is the purpose of this paper to discuss the conditions where ground preference is required. The paper discusses specific system conditions which would cause trouble if the phase relays were not superseded by the ground relays. There are, also, certain conditions where the presence of ground preference causes undesirable results. These onditions are discussed and solutions pro-osed. Certain other system conditions hich require phase-relay preference rather han ground-relay preference are discussed.

4-56—A 500,000-Kva 7.5-Kv Air Circuit reaker for Steel-Mill Service; *R. C. ickinson (M '41). 15 cents.* Heretofore it as not been economically feasible to build a elf-contained air circuit breaker for a rating f 500,000 kva at 7.5 kv. The developments eading to this rating are described. Also, description of the breaker and the peculiar esign problems are presented. Test data vith oscillograms are shown.

4-68—System Voltages and Fault Cur-ents Determined Easily on D-C Board; *. E. Asbury (A '39). 20 cents.* A systematic nethod of procedure is outlined for obtaining ymmetrical components of voltages and urrents on the d-c calculating board. The ositive-sequence network and a zero-sequence network with impedances reduced to ne half are used. An analysis is given showng how all the necessary currents and voltges can be obtained simply from readings aken on these two networks.

Safety

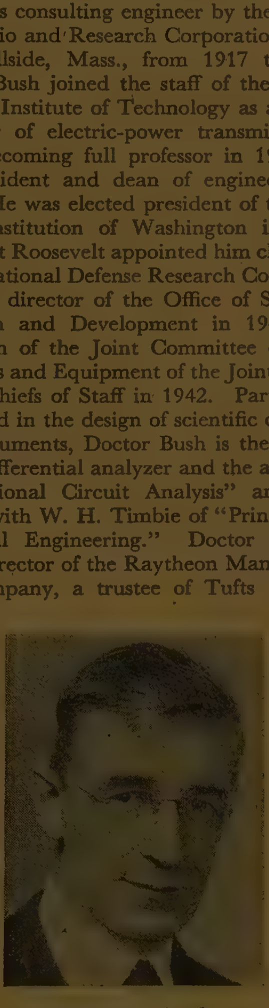
4-22—Study of Artificial Respiration on Anesthetized Men; *W. B. Kouwenhoven (F '34), D. R. Hooker, J. A. York. 15 cents.* This paper describes the results of a study in which the Schaefer prone-pressure method, the modified prone-pressure method in which the hands are rolled or snapped off the subject's back, and the pole-top method were applied o anesthetized men. Three subjects were used in the investigation. The subject's normal breathing and his chest expansion and contraction were first measured in a conscious condition. While the subject was still concious all three methods of artificial respiraion were applied. Following this the aneshetic was given and when the subject was inconscious and completely relaxed the three rtificial respiration tests were repeated. It was found that the air moved per respiration under artificial respiration is equal to or greater than the natural breathing of the conscious subjects and that all three methods of artificial respiration provide ample ventilation of the lungs, the pole-top method being lightly in the lead.

Domestic and Commercial Applications

4-69—The Vibration of Electrical Conacts; *M. N. Russell, Saul Keilien. 15 cents.* Objectionable effects of electrical contacts' vibrating during their "making" period are discussed. Contacts that do not "make" without vibration or without bouncing horten the life of switching devices considerbly, particularly in circuits involving high nitial power surges. Means for suppression f contact vibration are discussed. The practical solution is given for knife-type contacts. Graphical explanation of preloaded contact prings is given. Tests of switching devices having properly designed contacts disclosed xceedingly long life, even when controlling ircuits contained lamps as load.

PERSONAL ● ● ● ●

Vannevar Bush (A '15, F '24) president, Carnegie Institution of Washington (D. C.), and Director of the Office of Scientific Research and Development has been awarded the Edison Medal for 1943 for "his contribution to the advancement of electrical engineering, particularly through the development of new applications of mathematics to engineering problems, and for his eminent service to the Nation in guiding the war research program." Doctor Bush, the 33d recipient of the Medal, was born in Everett, Mass., March 11, 1890, and was graduated from Tufts College with the degrees of bachelor and master of science in 1913; he has received honorary doctorates from that institution and from nine other leading colleges and universities. Previously he received the Levy Medal of the Franklin Institute (1928), the AIEE Lamme Medal (1935), the Holley Medal of the American Society of Mechanical Engineers, and the John Scott Medal of the Philadelphia City Trustees (1943). His first position was in the testing department of the General Electric Company, Schenectady, N. Y., in 1913. After a short time with the inspection department of the United States Navy, he was appointed to the faculty of Tufts College in 1914 as instructor in mathematics and in 1916 was made assistant professor of electrical engineering. In 1918 and 1919 he was engaged in research on submarine detection for the United States Navy. He was employed as consulting engineer by the American Radio and Research Corporation, Medford Hillside, Mass., from 1917 to 1922. Doctor Bush joined the staff of the Massachusetts Institute of Technology as associate professor of electric-power transmission in 1919, becoming full professor in 1923 and vice-president and dean of engineering in 1932. He was elected president of the Carnegie Institution of Washington in 1939. President Roosevelt appointed him chairman of the National Defense Research Committee in 1940, director of the Office of Scientific Research and Development in 1941, and chairman of the Joint Committee on New Weapons and Equipment of the Joint United States Chiefs of Staff in 1942. Particularly interested in the design of scientific calculating instruments, Doctor Bush is the builder of the differential analyzer and the author of "Operational Circuit Analysis" and joint author with W. H. Timbie of "Principles of Electrical Engineering." Doctor Bush is also a director of the Raytheon Manufacturing Company, a trustee of Tufts College, Brookings Institution, and the Woods Hole Oceanographic Institution; a regent of the Smithsonian Institution; a life member of the Massachusetts Institute of Technology Corporation; and a member of the business advisory council of the United States Department of Commerce (1939–41). His society affiliations include membership in the American Association for the Advancement of Science, the American Physics Society, the American Academy of Arts and Sciences, the American Philosophical Society, the American Society of Mechanical Engineers, and the Society for the Promotion of Engineering Education. He also is a member of Tau Beta Pi, sigma Xi, and Phi Beta Kappa.



Vannevar Bush

A. N. Goldsmith (M '15, F '20) consulting engineer, New York, N. Y., has been appointed vice-chairman of the Radio Technical Planning Board. Doctor Goldsmith received the degrees of bachelor of science from the College of the City of New York (1907), doctor of philosophy from Columbia University (1911), and the honorary degree of doctor of science from Lawrence College (1935). He was attached to the faculty of the College of the City of New York (N. Y.) from 1906 to 1923. He has been director of research for the Marconi Wireless Company of America (1917–19), and director of research, chief broadcast engineer, and vice-president of the Radio Corporation of America, New York, N. Y., (1919–33), and is the holder of more than 100 patents. Doctor Goldsmith is a charter member and fellow of the Institute of Radio Engineers, a member of that society's board of directors, and editor of the *Proceedings* of the IRE.

J. J. Booth (A '13, F '39) formerly assistant superintendent, maintenance department, Carnegie-Illinois Steel Corporation, Duquesne, Pa., has been appointed superintendent of that department. Mr. Booth has been associated with subsidiaries of the United States Steel Corporation since 1913 when he entered the electrical-engineering department of the Carnegie Steel Company's Edgar Thomson Works. He was transferred to the National Tube Company, Gary, Ind., in 1924 where he was assistant superintendent and later superintendent of the electrical department. Transferred to the Carnegie-Illinois Corporation in 1935, he became assistant superintendent of maintenance.

Tomlinson Fort (A '27, M '35) formerly assistant manager, central station sales department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., has been appointed manager of the central-station department. Employed by the Westinghouse company since 1923, Mr. Fort was assigned to the sales department until 1927 when he was transferred to Albany, N. Y. From 1931 to 1940 he was attached to the company's New York, N. Y., office and in 1940 became assistant manager of the central-station department.

William Marcus Potts (A '36) chief electrician, Pacific Coast Borax Company, Boron, Calif., is not the William M. Potts who died in June 1943 as was erroneously reported in the November 1943 issue of *Electrical Engineering*. The latter was not an AIEE member.

F. E. Kulman (A '30, M '39) formerly junior engineer, electrical-engineering department, Consolidated Edison Company of New York (N. Y.), Inc., now a lieutenant in the United States Navy, is stationed at the Brooklyn (N. Y.) Navy Yard.

OBITUARY

Hamilton Gray Scott (A '11, M '15) former public-utility executive, died November 1, 1943, in New York, N. Y. Mr. Scott, who was born in Paterson, N. J., December 29, 1882, commenced his career as chief electrician for the Rogers Locomotive Works in Paterson, in 1905. In 1908 he was employed as a salesman for the Fletcher Stanley Company and from 1909 to 1912 by the Shelby (Ohio) Electric Company as salesman and southern sales manager. During 1912 he had charge of the power contracts for the Central Georgia Power Company, Atlanta. He held the positions of general manager and vice-president of the Virginia Power Company from 1912 to 1915 and that of vice-president from 1915 to 1918. Joining the Charleston Industrial Corporation in 1918 as president, he became chairman of the board in 1923. From 1923 to 1925 he was also president of the Columbia Gas and Electric Company and its subsidiaries. He organized the Fidelity Public Service Company, which eventually became the Public Service Company in 1927, and later organized the Memphis National Gas Company. He was chairman of the board of the Servel Corporation and helped form the Electrolux Servel Corporation. In addition he served as vice-president of the Union Gas and Electric Company and the United Fuel Company. He retired in 1926 but retained directorships in several corporations and in 1941 returned to active work to convert the Pathe Engineering and Tool Manufacturing Company, Long Island City, N. Y., to war production.

Howard Arthur Stanley (A '07, M '19) plant engineer, Berkshire Fine Spinning Associates, Providence, R. I., died October 18, 1943. Mr. Stanley, who was born July 6, 1884, in Beverly, Mass., received the degree of bachelor of science in electrical engineering from the University of Maine in 1905. He worked in the testing and construction department of the Stanley-G. I. Electric Manufacturing Company, Pittsfield, Mass., until 1907. He was employed as construction foreman for the General Electric Company in Schenectady, N. Y., from 1907 to 1909, and in Boston, Mass., from 1910 to 1912, and was transferred to the district engineer's office in 1912. Joining the Fall River (Mass.) Electric Light Company in 1914 as electrical engineer, he became general superintendent in 1916 and vice-president in 1928. In 1930 he was employed by the New England Power Engineering and Service Corporation, Boston. He commenced his association with the Berkshire Fine Spinning Associates in 1933 at Fall River and in 1937 was transferred to Providence, R. I. An active member of the AIEE Providence Section since its organization in 1920, Mr. Stanley served as Section chairman (1923–4) and at some time had been a member of each of the Section's committees.

Roy Edwin Reid (A '12) engineer, Portland, Oreg., died in October 1942. Born February 14, 1880, in Jacksonville, Ill., Mr. Reid attended the University of California. From 1900 to 1904 he was a tester in the electrical department of the Union Iron Works, San Francisco, Calif. In 1910 he worked as electrician for Natomas Consolidated of California and in 1911 for the Pacific Light and Power Corporation, Redondo Beach, Calif., and on the Los Angeles Aqueduct, Inyo-Kern, Calif. He was employed as electrician by the Powder River Gold Dredging Company, Sumpter, Oreg., from 1913 to 1922. Joining the South Park Dredging Company in 1922 he was employed as electrician at Fairplay, Colo., and from 1924 to 1928 as assistant superintendent at Featherville, Idaho, and Ashland, Oreg. He worked as an electrician for the Northwestern Electric Company, Portland, Oreg. from 1929 to 1933. In 1934 he was employed as engineer by the La Grange (Calif.) Gold Dredging Company and the Yuba Consolidated Gold Fields and became assistant superintendent for the latter company in 1935. In 1939 he was transferred to the operating department in Durham, Calif.

James Watt Cochrane (A '42) erecting engineer, Canadian General Electric Company, Ltd., Toronto, Ont., died November 6, 1943. He was born September 5, 1894, in Kincardine-on-Forth, Scotland, and started working as an apprentice in mechanical and electrical engineering for Robert Melvin and Sons, Alloa, Scotland, in 1908. In 1913 he went to sea for the J. R. Ellerman City Line operating in the East Indian trade as junior and senior engineer. From 1915 to 1918 he served in His Majesty's Royal Naval Reserve as engineer sublieutenant and was decorated with the Distinguished Service Order. From 1919 to 1921 he was employed as marine engineer by the Union Castle Mail Steamship Company and from 1921 to 1923 was occupied in erecting a turbogenerating station in Tanganyika Territory, East Africa, for the Metropolitan-Vickers Company, Ltd. Since 1924 he had been employed as construction engineer by the Canadian General Electric Company.

Frederick Hormah Reid (M '28) president of the Mountain States Telephone and Telegraph Company, Denver, Colo., died October 29, 1943. Mr. Reid was born in Inverness, Scotland, April 6, 1880. His first association with the telephone industry was as clerk to the superintendent of the Colorado Telephone Company, Denver, in 1902. In 1904 he was made chief clerk to the general superintendent and in 1907 chief clerk to the general manager. He joined the Mountain States company as assistant to the general manager in 1914, and in 1915 became assistant general manager. He was appointed general manager in 1920. After serving as vice-president of the Southern Bell Telephone and Telegraph Company, Atlanta, Ga., from 1922 to 1924, he returned to the Mountain States company as president. Mr. Reid was a former president of the Telephone Pioneers of America.

MEMBERSHIP

Recommended for Transfer

The board of examiners, at its meeting on December 22, 1943, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

Brandon, M. M., associate elec. engr., Underwriters Labs., Inc., New York, N. Y.
Schilling, E. W., head, dept. of elec. engg., and Dean of engg., Montana State College, Bozeman, Mont.
Shuler, Wm., mgr., elec. engg., Records, inspection, and testing div., Dayton Power & Light Co., Dayton, Ohio.

3 to grade of Fellow

To Grade of Member

Albrecht, H. C., asst. chief engr., Philadelphia Electric Co., Philadelphia, Pa.
Arndt, M. H., head, Steam Plants Unit, Rural Electrification Adm., St. Louis, Mo.
Beichley, F. W., district engr., Westinghouse Elec. & Mfg. Co., San Francisco, Calif.
Bennett, W. R., member of technical staff, Bell Telephone Labs., Inc., New York, N. Y.
Blackburn, J. L., relay application engr., Westinghouse Elec. & Mfg. Co., Newark, N. J.
Boldt, W. F., elec. engr., Curtiss-Wright Corp., Robertson, Mo.
Broekhuysen, W. C., elec. engr., American Machine & Foundry Co., Brooklyn, N. Y.
Brown, W. A. R., Section chief, RCA Frequency Bureau, New York, N. Y.
Cassell, W. L., prof. of elec. engg., Iowa State College, Ames, Iowa.
Cavagnaro, A. E., engr., Columbia Engg. Corp., Cincinnati, Ohio.
Cline, R. F., research elec. engr., Norton Co., Chippawa, Ont., Can.
Cole, J. D., elec. engr., Russell Electric Co., Chicago, Ill.
Daily, C. F., engr., American Tel. & Tel. Co., Cincinnati, Ohio.
Davis, R. F., engr., American Tel. & Tel. Co., New York, N. Y.
Harmer, W. R., supervising industrial engr., Hydroelectric Power Comm. of Ontario, Toronto, Can.
Herring, F. M., senior engr., Baltimore Transit Co., Baltimore, Md.
Horn, R. C., engr., Southwestern Bell Telephone Co., St. Louis, Mo.
Lane, R. A., investigator of plant tests, Conowingo Hydro Plant, Conowingo, Md.
Lutz, R. F., consulting engr., Black & Veatch, Kansas City, Mo.
Mascott, Luis, engr. and professor, Mexico, D. F., Mexico.
May, M. S., service mgr., Speer Carbon Co., St. Mary's, Pa.
McCann, G. D., transmission engr., Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.
McMains, T. F., division traffic supt., Western Union Telegraph Co., New York, N. Y.
Menut, J. G., principal engr., (P-6) Power Section, War Department, Washington, D. C.
Miller, E. F., elec. engr., Iowa Illinois Gas & Elec. Co., Rock Island, Ill.
Phillips, A. H., chief elec. engr., Gilbert Associates, Inc., Reading, Pa.
Pierson, W. H., elec. designer, Chemical Construction Corp., New York, N. Y.
Richardson, A. G., senior engr., Federal Telephone & Radio Labs., New York, N. Y.
Schroeder, T. W., elec. engr., General Electric Co., Schenectady, N. Y.
Shelby, R. E., development engr., National Broadcasting Co., New York, N. Y.
Shipley, R. B., asst. elec. engr., U. S. Navy Yard, Philadelphia, Pa.
Smith, F. W., associate professor of elec. engg., Lafayette College, Easton, Pa.
Streifus, C. A., elec. engr., Ebasco Services, Inc., New York, N. Y.
Sunde, E. D., member of technical staff, Bell Telephone Labs., Inc., New York, N. Y.
Uhlendorf, E. D., vice-president, Public Utility Engg. & Service Corp., Chicago, Ill.
Zuch, H. W., chief elec. engr., University of Texas, Austin, Texas.

36 to grade of Member

Applications for Election

Applications have been received at headquarters from the following candidates for election to membership in the Institute. Names of applicants in the United States and Canada are arranged by geographical District. Any member objecting to the election of any of these candidates should so inform the national secretary before December 31, 1943, or February 31, 1944, if the applicant resides outside of the United States or Canada.

To Grade of Member

Adams, J. T. (Reelection), Pub. Service Co. of Okla., McAlester, Okla.

aier, J. F., E-J Electric Installation Co., Louisville, Ky.
ottini, S. D., A. Neri, Inc., Hoboken, N. J.
urtiss, W. R., Great American Industries, Meriden, Conn.
onald, D. D., American Tel. & Tel. Co., New York, N. Y.
ouglass, D. D., Chevrolet Gear & Axle Div. of G. M., Detroit, Mich.
rago, F. G. S., British Admiralty Tech. Mission, Ottawa, Ont., Can.
rummond, W. D. (Reelection), Westinghouse E. & M. Co., Cincinnati, Ohio.
unlop, C. E., Perron Gold Mine, Ltd., Perron, Que., Can.
aston, E. C. (Reelection), Harvard Univ., Cambridge, Mass.
theridge, H. L. (Reelection), Senior Electrical Engineer, U. S. Army, New York, N. Y.
yford, C. T., British Columbia Elec. Ry. Co., Ltd., Vancouver, B. C., Can.
eldman, J. G. (Reelection), Rolins Co., New York, N. Y.
laherty, E. B., Lieut. Comdr., USNR, New York, N. Y.
rost, D. K., Mattison Machine Works, Rockford, Ill.
ates, J. L., Petroleum Adm. for War, Washington, D. C.
laygarth, R. H., Dravo Corp., Pittsburgh, Pa.
eller, R. A., Central Ill. Light Co., Peoria, Ill.
ennell, J. P., Tenn. Valley Authority, Knoxville, Tenn.
ent, W. (Reelection), General Electric Co., Fort Wayne, Ind.
ewley, R. K., J. I. Case Co., Rockford, Ill.
umbo, E., Brewster Aeronautical Corp., Long Island City, N. Y.
ocke, M. W., Commonwealth Edison Co., Pekin, Ill.
ukey, M. E., Public Service Co. of Northern Ill., Chicago, Ill.
loore, M. M. (Reelection), Federal Power Commission, Washington, D. C.
icholas, T. E., Simmons Aerocessories, Long Island City, N. Y.
oulter, R. C., Hugh McLean Publications, Ltd., Toronto, Ont., Can.
rice, J. B. (Reelection), Johnson Fan & Blower Corp., Chicago, Ill.
oss, F. U., Virginia Elec. & Pr. Co., Portsmouth, Va.
t. John, M. C., U. S. Engineer Office, Galveston, Texas.
aveland, B. W., The Austin Co., Cleveland, Ohio.
choel, W. A. (Reelection), Boeing Aircraft Co., Seattle, Wash.
chon, E. B., Allis-Chalmers Mfg. Co., West Allis, Wis.
mith, F., Supt. of Fire Alarm, City of Tulsa, Okla.
mythe, K. R., Glenn L. Martin Co., Baltimore, Md.
ullivan, W. G., Research Corp., Bound Brook, N. J.
hompson, H. H., Indiana Bell Tel. Co., Indianapolis, Ind.
Valkup, J. F., Parkhill-Wade, Los Angeles, Calif.
Vallace, W. H., Brooklyn Edison Co., Brooklyn, N. Y.
Vard, D. J., Ward Research Products Co., Sherman Oaks, Calif.
Vendt, W., Gulf States Utilities Co., Beaumont, Texas.
Vieking, W. C., R. Hoe & Co., Inc., New York, N. Y.

2 to grade of Member

To Grade of Associate

United States and Canada

1. North Eastern

ernard, J. A., Bethlehem-Hingham Shipyard, Inc., Hingham, Mass.
ichelberger, W. F., Central N. Y. Power Corp., Syracuse, N. Y.
uile, M. E., Jr., Gen. Elec. Co., Schenectady, N. Y.
liller, L. M., Eastman Kodak Co., Rochester, N. Y.

Middle Eastern

arger, C. A., American Shipbuilding Co., Lorain, Ohio.
aylis, A. H., Westinghouse E. & M., East Pittsburgh, Pa.
lair, F. O., B. F. Goodrich Co., Akron, Ohio.
handler, A. H., Consolidated Gas Elec. Lt. & Pr. Co. Baltimore, Md.
ickhoff, O., Jr., I-T-E Circuit Breaker Co., Philadelphia, Pa.
opp, F. C., Bethlehem Steel Co., Sparrows Point, Md.
ovach, L. D., American Shipbuilding Co., Cleveland, Ohio.
ang, M. T., West. E. & M. Co., Baltimore, Md.
lacKenzie, K. W., West. E. & M. Co., Cleveland, Ohio.
lann, C. A., West. E. & M. Co., Cleveland, Ohio.
lcAdie, C. H., Monitor Controller Co., Baltimore, Md.
lumma, R. E., National Cash Register Co., Dayton, Ohio.
iedeck, J. A., Lehigh Valley R.R., Bethlehem, Pa.
utram, R. A., American Aircraft Associates, Dayton, Ohio.
artridge, P. N., U. S. Navy Dept., Washington, D. C.
adcliffe, G. B., Trumbull Elec. Mfg. Co., Norwood, Ohio.
acksteder, A. J., Frigidaire Plant #2, Moraine, Ohio.
cheide, C. W., American Shipbuilding Co., Lorain, Ohio.
hockney, J. M., Greenville Elec. Light & Power Co. & Affiliated Companies, Greenville, Ohio.
mith, E. R., Ohio Pub. Service Co., Warren, Ohio.
mith, H. C., Bell Tel. Labs., Inc., Cleveland, Ohio.
towe, R. E., Westinghouse E. & M. Co., Dayton, Ohio.
ibbs, R. H. (Reelection), Chesapeake & Potomac Tel. Co., Washington, D. C.
urnbull, E. H., Jr., Naval Research Lab., Washington, D. C.

3. New York City

Alholm, A., S. S. White Dental Mfg. Co., Staten Island, N. Y.
Anderson, F. C. (Reelection), T. A. Edison, Inc., West Orange, N. J.
Batt, L. T. (Reelection), Pub. Serv. Elec. & Gas Co., Newark, N. J.
Brauner, O. A., Gielow, Inc., New York, N. Y.
Camp Sergei, N., Lieut., U. S. Army, Middle Village, N. Y.
Causin, R., Standard Switchboard Co., Brooklyn, N. Y.
Cipriano, C. J., 46 Davis Road, Port Washington, N. Y.
Cline, D. E., Signal Corps Laboratories, Eatontown, N. J.
Colman, A., Electro Tech. Labs., Inc., Leonia, N. J.
Davis, F., Wright Aeronautical Corp., Woodridge, N. J.
Duell, P. G., F. L. Smidth & Co., New York, N. Y.
Dusenberry, C. K., Wright Aeronautical Corp., Woodridge, N. J.
Eckert, J. R., Wright Aeronautical Corp., Woodridge, N. J.
Farrell, R. P., Ward Leonard Elec. Co., Mt. Vernon, N. Y.
Forsberg, A. W., Gen. Aviation Equip. Co., New York, N. Y.
Goldman, S., Bogue Elec. Co., Paterson, N. J.
Hagen, T. O. S., Board of Transportation, City of New York, N. Y.
Hammell, S. C., Wright Aeronautical Corp., Woodridge, N. J.
Hill, L. P., Federal Tel. & Radio Corp., East Newark, N. J.
Jones, M. A., N. J. Bell Tel. Co., Newark, N. J.
Katibah, E. E., Cons. Edison Co. of N. Y., Inc., New York, N. Y.
King, E., Todd Shipyards Corp., Hoboken, N. J.
Kraus, C. T., Gielow, Inc., New York, N. Y.
Krommenhoek, C., Todd Shipyards Corp., Hoboken, N. J.
Larkin, J., Century Elec. Co., New York, N. Y.
Lucas, W., General Cable Corp., Perth Amboy, N. J.
Marino, D. A., George G. Sharp, New York, N. Y.
Matthews, M. T., Standard Oil Co. of N. J., Elizabeth, N. J.
Metz, R. P., Westinghouse E. & M. Co., Newark, N. J.
Morrison, J. W., Pub. Service Elec. Lab., Maplewood, N. J.
Neri, J. M. (Reelection), A. Neri, Inc., Hoboken, N. J.
Nordlindh, H., Gibbs & Hill, Inc., New York, N. Y.
Offrell, T., F. L. Smidth & Co., New York, N. Y.
Oseroff, D. M. (Reelection), J. G. White Engg. Corp., New York, N. Y.
Schultheis, T. W., Bell Tel. Labs., Inc., New York, N. Y.
Somers, F. C., Standard Oil Dev. Co., Elizabeth, N. J.
Swedlow, S., C. J. Tagliabue Co., Brooklyn, N. Y.
Taylerson, J. E., Federal Shipbldg. & Dry Dock Co., Port Newark, N. J.
Vine, E. L. (Reelection), James Stewart & Co., New York, N. Y.
Volavka, W., Long Island Ltg. Co., Mineola, N. Y.
Wendelken, G. J., Sperry Gyroscope Co., Brooklyn, N. Y.
Wertz, R. J., Cameron Mach. Co., Brooklyn, N. Y.
Yates, F. A., Diehl Mfg. Co., Somerville, N. J.
Young, T. J. (Reelection), Bell Tel. Labs., Inc., New York, N. Y.
Zeese, A. C., Cons. Edison Co. of N. Y., Inc., New York, N. Y.
Zugale, P. J., N. J. Bell Tel. Co., Newark, N. J.

4. Southern

Adams, R. B., Tenn. Valley Authority, Knoxville, Tenn.
Alleman, J. J., Mathieson Alkali Works, Lake Charles, La.
Barnette, N. H., Louisiana Poly. Tech. Inst., Ruston, La.
Bell, P. M., Holston Ordnance Works, Kingsport, Tenn.
Brown, D. M., Tenn. Valley Authority, Chattanooga, Tenn.
Freeland, W. T., Freeland & Olschner Prod., Inc., New Orleans, La.
Griffith, J. C., General Electric Supply Corp., Shreveport, La.
Hoffman, G. H., Allis-Chalmers Mfg. Co., Knoxville, Tenn.
Kirby, L. W., U. S. Engr. Office, Norfolk, Va.
Moore, L. F., Knoxville Elec. Pr. & Water Board, Knoxville, Tenn.

5. Great Lakes

Bridgeman, M. J., A. O. Smith Corp., Milwaukee, Wis.
Canepa, T. T., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Crouch, A. W., Allison Div., General Motors Corp., Indianapolis, Ind.
Dernbach, C. R., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Dowling, J. J., Gen. Elec. X-Ray Corp., Chicago, Ill.
Hoot, H. M., Howell Electric Motors Co., Howell, Mich.
Larsen, O. F., Harnischfeger Corp., Milwaukee, Wis.
Lowman, C. S., Commonwealth Edison Co., Chicago, Ill.
Martin, C. R., Allis-Chalmers Mfg. Co., Milwaukee, Wis.
McAleer, G. H., Commonwealth Edison Co., Chicago, Ill.
Moyer, C. O., South Bend Elec. Co., Inc., South Bend, Ind.
Pelishek, R. A., Allis-Chalmers Mfg. Co., West Allis, Wis.
Powers, R. I., Wisconsin Electric Power Co., Milwaukee, Wis.
Ray, L. L., General Electric Co., Fort Wayne, Ind.
Rockafellow, S. C., A-C Spark Plug Div., General Motors Corp., Flint, Mich.
Wallace, R. S. (Reelection), Central Illinois Light Co., Peoria, Ill.
Sarec, M. J., Oliver Farm Equip. Co., South Bend, Ind.
Schindler, C., Kyle Corp., South Milwaukee, Wis.
Seymour, C. E., Hercules Powder Co., Baraboo, Wis.
Stukey, D. C. (Reelection), Public Serv. Co. of Northern Ill., Evanston, Ill.
VanRyan, A. (Reelection), Kyle Corp., So. Milwaukee, Wis.
Velde, R. L., Illinois Inst. of Tech., Chicago, Ill.
Wurgler, J., Allis-Chalmers Mfg. Co., Milwaukee, Wis.

7. South West

Anthony, W. F., S. W. Bell Tel. Co., St. Louis, Mo.
Benson, C. V., Pub. Service Co. of Okla., Tulsa, Okla.
Campbell, M. P., North American Aviation, Kansas City, Kans.
Ely, W. F., Univ. of New Mexico, Albuquerque, N. Mex.
Leary, H. P., Rural Elec. Adm., St. Louis, Mo.
Lyttle, W. P., Beech Aircraft Corp., Wichita, Kans.
May, H. L., S. W. Bell Tel. Co., St. Louis, Mo.
Mills, J. O., Pub. Service Co. Okla., Tulsa, Okla.
Stuart, J. F., El Paso Electric Co., El Paso, Texas.
Wiley, J. B., Univ. of Oklahoma, Norman, Okla.
Woodson, R. K. (Reelection), Kansas City Pr. & Lt. Co., Kansas City, Mo.

8. Pacific

Byström, A. F., Western Union Tel. Co., Los Angeles, Calif.
Eggers, F. A., Gen. Elec. Co., Los Angeles, Calif.
Gunderson, M. F., Douglas Aircraft Co., El Segundo, Calif.
Miller, D. L., Douglas Aircraft Co., Santa Monica, Calif.
Rife, J. E., Bureau of Power & Light, City of Los Angeles, Calif.
Smithen, W. E., Jr., General Engg. & Dry Dock Co., Alameda, Calif.

9. North West

Beadle, T. W., Lieut., U. S. Army, Seattle, Wash.
Bolluyt, M. A., Lieut., U. S. Army, Seattle, Wash.
Cultum, G. L., Austin Co., Seattle, Wash.
Gregg, T. S., Bonneville Power Admn., Portland, Oreg.
Hanson, L. P., Boeing Aircraft Co., Seattle, Wash.
Scoville, C. J. (Reelection), Portland Gen. Elec. Co., Portland, Oreg.
Templeton, L. F., Boeing Aircraft Co., Seattle, Wash.

10. Canada

Barr, W. G. A., Norton Co., Niagara Falls, Ont., Can.
Lees, D., Canadian Westinghouse Co., Ltd., Toronto, Ont., Can.
Robertson, T. C., Int'l Nickel Co., Ltd., Copper Cliff, Ont., Can.

Elsewhere

Adams, A. J. (Reelection), U. S. Govt., Seward, Alaska.
Aguirre Torres, J., General Electric, S. A., Mexico, D. F., Mex.
Campos Efrain, N., Int'l Automatic Elec. Corp., Mexico, D. F., Mex.
Ceballos, E. D., Cia. de Luz y Fuerza de Tehuacan, Tehuacan, Pue., Mex.
Cerda, J. M., Consulting Engineer, Mexico, D. F., Mex.
Cordero Gutierrez, E., Westinghouse Elec. Int'l Co., Mexico, D. F., Mex.
Dogra, H. C., S. D. O. E. & M. (A), Khamaria, Jubbulpore, C. P., India.
Doughman, G. B., General Electric, S. A., Monterrey, N. L., Mex.
Frias, Guzman, L., Cenetro Electrico, SRL, Puebla, Pue. Mex.
Garate Valdes, V., Santa Maria de la Paz y Anexas, S. A., Matehuala, S. L. P., Mex.
Garcia Acosta, J., Industrial Electrica de Soconusco, S. A., Tapachula, Chis., Mex.
Gonzalez Campos, E., Electrical Engineer, Torreon, Coah., Mex.
Guzman, C. V., National Economy Secrty, Mexico, D. F., Mex.
Hanff Castellanos, L., New Tequixquiac Tunnel, Mexico, D. F., Mex.
Horrocks, P., British Post Office Engg. Dept., Bolton, England.
Morales Garza, G., Railway Div., Mexican Government, Mexico, D. F., Mex.
Nieto, P. E., Comision Federal de Electricdad, Mexico, D. F., Mex.
Padilla de la Pena, A., Construccion y Maquinaria, Mexico, D. F., Mex.
Padilla Soto, F., Fabrica de Ceremica Ind., "El Aguila," Mexico, D. F., Mex.
Portugal Perez, J., Maquinaria y Materiales Electricos, Mexico City, D. F., Mex.
Rangel L., R., Sociedad Electro-Mecanica S. de R. L., Mexico, D. F., Mex.
Rosales de la Mora, A., Fabrica Nacional de Polvora, Sante Fe, D. F., Mex.
Souza Quevedo, V. (Reelection), Electrical Contractor, Mexico, D. F., Mex.
Taylor, W. H., General Electrica, S. A., Mexico, D. F., Mex.
Torres Aranda, F. (Reelection), Communications & Pub. Utilities Dept., Mexico, D. F., Mex.
Ulloa Arriola, C., Municipal Water Service, Mexico, D. F., Mex.
Villareal, E. M., Brown Boveri & Co., Mexico, D. F., Mex.
Zironi, E. W., EJE-Ingenieros, F. N. I., Mexico, D. F. Mex.

Total to grade of Associate

United States and Canada, 134
Elsewhere, 28

OF CURRENT INTEREST

ASCE Adopts Procedure for Collective Bargaining

Of significance to engineering employees in all fields of the profession was the action taken by the board of direction of the American Society of Civil Engineers at its recent meeting in Atlanta, Ga., when it approved and adopted a procedure for establishing collective-bargaining agencies for "professional engineering employees."

Upon the basis that the principle of collective bargaining has gained widespread acceptance in the past decade, and that its continued application is as inevitable as it is restrictive of the prerogatives of professional status, the board acted to assure ASCE members bargaining representation in groups of their own choosing. In past instances when professional engineers have failed to act together, nonprofessionals have assumed the right to bargain for them and have been given that right by the War Labor Board. Formation of a group which will be recognized legally as the collective bargaining agent exclusively for professional engineers was the only alternative to bowing before the authority vested in other unions of a subprofessional or nonprofessional level.

Long under consideration, the board's action was precipitated by the recent refusal of a War Labor Board panel at Kansas City, Mo., to recognize a group of about 100 engineers as a separate bargaining unit at the Sunflower Ordnance Plant. The reason given for the refusal was that the International Federation of Technical Engineers, Architects, and Draftsmen's Unions had been recognized for almost a year as spokesmen for technical men on the job. Inference from the panel's findings being that the engineering group would have been entitled to separate recognition had it acted when the matter of representation first was under consideration, the ASCE has prepared the foundation for organization against the time when concerted action shall be needed.

As recommended by the board of direction, the local sections of the ASCE will amend their constitutions so as to provide for engineering employees within their respective areas to form such employee bargaining groups. The Society will act as a national co-ordinating agency, and to this end will subscribe $50,000 annually for the maintenance of four field representatives, to be operative in each of the Society's zones, who will organize, advise, and assist the local groups. Moreover, in many cases, they may find it practicable to conciliate differences without the aid of the proposed bargaining groups.

At the start the local collective bargaining agency will be a subsidiary of the local ASCE section, but provision is made for nonmembers of the ASCE who are otherwise eligible to become affiliated. It is proposed to exclude from membership in the bargaining groups subprofessional men engaged in engineering work, and also, qualified professional engineers whose present positions place them in the employer rather than the employee category. To this end, the board of direction has formulated the following definition:

> The designation "professional engineering employees" . . . shall be that of only those who . . . possessing an intimate knowledge of mathematics and the physical sciences gained by technological and scientific education, training, and experience, and in a position of trust and responsibility, apply their knowledge in controlling and converting forces and materials to use in structures, machines, and products, and whose work requires the exercise of discretion and judgment, is creative and original and of such character that the output cannot be standardized; and those who, without the experience set forth, but having been graduated from an approved educational institution and having received the degree of bachelor of science or its equivalent, in engineering, are engaged in engineering work.

Dues have been tentatively set at $1 per year for members of the ASCE and "preferably not to exceed $5 per year" for non-ASCE members. The bargaining committee will have the duty and power to direct all activities looking toward the acquisition of adequate compensation and satisfactory working conditions for all professional engineering employees resident within the geographical limits of the local section in accordance with the general direction of its members.

WPB Opens Campaign to Augment Dwindling Paper Supply

With the waning of the first enthusiasm for salvage pervading the public in the days immediately following Pearl Harbor; the decline in man power available for curing wood pulp; and the sharp increase in military demand for paper by our widespread forces, the problem of paper supply has entered its crucial stage. According to War Production Board estimates, the success or failure, during the first six months of 1944 of its program of conservation by curtailment of the necessary uses of paper, and of salvage and re-use of waste paper should answer any questions about the severity of future curtailments.

An indication of the manner in which military demands have eaten into a civilian paper supply already below normal because of man-power shortages for timber cutting is found in the fact that for only the first year of the present war ten times the supplies and equipment used in 1917–18 were shipped abroad. Paper for shell containers, protectors, medical kits, food containers, clerical purposes, inner-packaging material, instrument panels, targets, component parts of bombs and fuses, gas-mask canisters, helmets, and building paper and board for cantonments can be secured by reprocessing waste paper. If the waste paper is not forthcoming, military demands will hold priority on wood pulp ordinarily used for printing. Compared with 43 tons of supplies per month per man in the last war, 81 tons of supplies must be packed monthly using one or more paper products, to keep each fighting man overseas in World War II. Since re-using waste paper performs the multiple duties of increasing the paper supply; of helping solve the scarcity of man power in the wood-pulp industry by directly replacing pulpwood; and of affording opportunity for larger numbers of people to assist in the paper program, the Government is giving wide publicity to the facts about the waste-paper salvage program in an effort to gain the co-operation of all. This latest program, unlike the successful February-March 1942 salvage campaign, is laboring under the added difficulty of diminished amounts of potential waste as a result of curtailment regulations already in force and the impossibility of recovering paper going to the fighting forces abroad.

One obstacle to the continuance of the last campaign has been eliminated. At that time, when the supply of waste paper was plentiful the mills engaged in converting waste paper were forced to curtail operations because of contract cancellations and manufacturing restrictions, and the resulting excessive supply broke the ceiling price for the paper. Under present agreements, eastern and western members of the waste-paper-consuming industries will purchase, at ceiling price, all paper collected and properly processed by February 15. These industries are faced with the necessity for an increase of 1,000,000 tons a year in waste-paper collections to offset a 50-per-cent drop in their inventories in the period of 12 months preceding September 1943.

Although the effect must be necessarily less immediate than that of waste salvage, since the war is largely responsible for the fall in production, the government is endeavoring to stimulate production of pulpwood. The Canadian paper industry which supplies nearly three fourths of our newsprint also i suffering from lack of man power to cut timber. In addition to this handicap Canada also has diverted electric power normally used in pulp and paper mills to other war factories, and in 1944 a still greater curtailment in Canadian production is anticipated. Pulpwood imports from Norway and Sweden cannot be resumed until the successful termination of the war i Europe. With no chance of increasing imports from these chief producers, other

easures have been taken by WPB. It has
onsored Congressional appropriation of
,000,000 and an equal expenditure by the
nited States Forest Service for the purpose
increasing production; backed efforts to
ake available prisoners of war to supple-
ent the short labor supply; and instigated
campaign to encourage production of pulp-
ood by farmers and small holders of timber.

In the conservation program launched
nultaneously with its salvage efforts, the
overnment recognizes two distinctly dif-
ent contributions which the general civilian
pulation and industry as such have to offer.
ne public as the prime user is in a position
effect the greatest saving of wrapping-
per tonnage. This can be accomplished if
s actively aware of the need for eliminating
unnecessary wrapping and is willing to
cept unwrapped parcels and to use its
n shopping containers whenever possible
its daily purchasing. Retailers naturally
e loath to insist on this saving against
stomer opposition. A reduction of 25
r cent in the use of wrapping paper and
gs by the public will mean an annual
ving of over 250,000 tons of paper. As
e main consumer of paperboard packaging
d container material, industry has been
quested to make its packaging wholly
nctional. Besides the over-all Government
ograms, many trade and industrial associa-
ns are conducting individual campaigns,
d it is anticipated that a conservation of
ore than 750,000 tons of paper will result
m these combined efforts. If the wood-
lp and waste-paper supply for the first
arter of 1944 is insufficient to support the
oduction of enough paper and paperboard
meet all demands, the demand will be
ought into balance with supply through
nitation orders restricting consumption of
per and paperboard by the less-essential
ers.

VAR PROGRAM ● ●

060-Mile Alaska Communication Line Now in Operation

A 2,060-mile communications line, linking
e United States and Alaska by telegraph
d telephone service along the entire
ngth of the Alaska Military Highway, said
be the second longest carrier-communica-
ons system in the world, was completed in
ovember 1943 and is now in operation.

The system, as well as the highway, was
ilt in little more than a year by the United
ates Army Signal Corps, with the assistance
Bell System engineers, installers, and con-
uction crews.

The first link from Edmonton, Alberta, to
awson Creek, B. C., a distance of 442 lines,
as started in November 1942. Five wire
e groups from the American Telephone
d Telegraph Company, Bell Telephone
ompany of Canada, and three other Bell
stem companies, together with a Signal
orps construction batallion of 140 men,
orking in temperatures ranging from 30
72 below zero, completed this section of
e line and established communications by
ecember 1, 1942.

The second link from Dawson Creek to
hitehorse in the Yukon Territory, covering a distance of 900 miles, was opened May 24, 1943. The third and final link, running some 650 miles from Whitehorse to Fairbanks, Alaska, was completed in November of 1943.

The complete 2,060-mile line carries two circuits which are expanded by *C*-type carrier systems so as to provide 7 talking channels and 14 teletypewriter circuits. Critical shortages of strategic metals made necessary the use of wire of only 30 per cent copper, which, however, was considered desirable because of the greater strength of the Copperweld wire. But to bring up the transmission conductivity it was necessary to use repeater stations every 95 miles instead of at the usual 200-mile interval.

The Alberta government telephone administration had previously attempted a radio link with the Yukon Territory, but "magnetic black-outs" made the attempt a failure. Atmospheric disturbances such as the Northern Lights interrupted radio transmission and reception during the winter days in the Arctic regions.

Latest Opportunities for Navy Commissions Listed

According to the latest Navy procurement bulletin, the opportunities for commissions and warrants, published in the December 1943 issue of *Electrical Engineering*, page 558, are still open to those qualified. The positions for which the number of candidates is still insufficient are: production expeditors, production analysts, inspectors of machinery, ship-repair engineers, naval academy instructors, antisubmarine engineers, and safety engineers. The requirements for an additional position for which some of our readers may be qualified follow:

S.P. 144-43 Job Analysis and Evaluation. Age 25 to 50. To be assigned to duty for the purpose of analyzing and evaluating civilian jobs and advising as to recruiting, placement, and classification of civilian personnel. Candidates must hold a degree from an accredited college and have had at least two years of recent intensive and progressively responsible experience in job analysis and evaluation work, or have had responsible administrative experience coupled with a thorough knowledge of job classification principles, regulations, methods, and problems. Preference will be given to those with a major in business administration or a background of engineering or accounting coupled with the foregoing experience. In the absence of a college degree, candidates must have had at least two years of college work and at least four years of the experience just described.

New Motor Designed to Increase Aircraft-Engine Production

An electric motor that revolves 1,000 times per second, said to be 20,000 rpm faster than any electric motor now being built for industrial use, has been developed by Robert M. Baker (M '40) Westinghouse Research Laboratories, to drive grinding wheels that put a mirror finish on hard-to-reach parts of airplane and tank engines and other war equipment. At present such grinders are powered by larger slower motors through belts and pulleys. The new motor will drive a grinder directly, eliminating production delays caused by breaking belts and increasing accuracy, often impaired by the sideward tug of the belt.

To meet the millionths-of-an-inch tolerance required in finishing aircraft-engine parts, the grinding wheel must cut effortlessly and smoothly, something that cannot be accomplished at low speeds. Many of these grinding wheels are less than an eighth of an inch in diameter, but they must attain high speeds at their grinding edge. Experience has shown that the best grinding speed is about a mile a minute on the face of the wheel.

Navy's Lamps Tested By Simulated Battle Blasts

No longer is it Navy shipboard routine to remove lamps from their sockets to stow them in safety before gunnery starts. The modern "rough service" lamps now in use on United States fighting craft are designed to withstand the concussion of heavy guns and permit interior quarters to remain lighted during an engagement.

The exceptional durability needed is assured in the plants of the Sylvania Electric Products, Salem, Mass., by testing the lamps on a "torture wheel" which reproduces the amount of shock to be sustained in service with the fighting fleet. Developed in line with the findings of the National Bureau of Standards, this wheel, about the size of an automobile wheel, is made of heavy steel with a ring of two dozen sockets in its outer rim. As it revolves, it drops spasmodically against a foil with a jar approximating a battleship's salvo. The lighted "rough service" lamps are maltreated in this fashion for from 3,800 to 7,600 poundings, depending on the wattage of the lamps.

Similar lamps are in demand for use on railroads, subways, and other places where heavy vibration and sharp shocks occur.

Sound-Powered Telephone Used for Combat Communications

A sound-powered telephone, operated without batteries and capable of carrying ten miles under favorable conditions, was used with great success on Guadalcanal, according to the War Department. Power in the telephone is generated by the human voice, and signaling is accomplished merely by whistling into the transmitter.

The equipment used on Guadalcanal was adapted to war communications by the Signal Corps from the commercially developed voice-powered telephone, and was installed on the island for fire control of infantry mortars and within infantry companies. It is smaller and more compact than battery-powered telephones and avoids the main disadvantage of these sets—deterioration of the batteries from the humidity and dampness of the South Pacific. Even under adverse conditions the set will carry messages five miles.

Periodicals Wanted for Foreign Libraries. A committee of the American Library Association is collecting scientific and technical journals for eventual shipment to foreign libraries and institutions unable to get them now because of the war. The committee is eager to acquire *Electrical Engineering*, and, since the Institute has no stock of several issues published during the past year, only through your gifts can copies be obtained. The committee will provide storage space if necessary. If you wish to help by donating your periodicals, please write to Dorothy J. Comins, executive assistant, Committee on Aid to Libraries in War Areas, Library of Congress Annex, Study 251, Washington 25, D. C.

JOINT ACTIVITIES

ASA to Join Allied Nations Group Announced at Silver Anniversary

Participation by the American Standards Association in an Allied Nations Standards Body was authorized by the ASA board of directors at its silver-anniversary meeting in New York, N. Y., held in December 1943. The organization of such a body to secure maximum possible co-ordination of standards necessary for the war effort and the immediate postwar period has been discussed informally for some time between the British Standards Institution, the Canadian Engineering Standards Association, the ASA, and key governmental agencies in the three countries. It is planned that a skeleton staff will be provided for the new organization with offices in London and either New York or Washington, D. C.

Officers for 1944, announced at the meeting, are:

Henry B. Bryans, executive vice-president, Philadelphia Electric Company, *President elect.*

George S. Case, chairman of board, Lamson and Sessions Company, *re-elected vice-president.*

H. S. Osborne, chief engineer, American Telephone and Telegraph Company, re-elected *chairman*, Standards council, which is in charge of all ASA technical work.

E. C. Crittenden, assistant director, National Bureau of Standards, re-elected, *vice-chairman*, Standards council.

Speakers at the meeting included Percy Good, director of the British Standards Institution, who brought the greetings of his organization to the meeting; Clifton E. Mack, director of procurement, United States Treasury Department, in charge of Government lend-lease purchasing; R. E. Zimmerman, vice-president of United States Steel Corporation and retiring president of ASA, who spoke on postwar changes and developments in the use of Standards in the United States and in international trade; and H. S. Osborne (F '21) chief engineer, operation and engineering department, American Telephone and Telegraph Company, New York, N. Y., and chairman of the Standards council.

During the past year ASA has approved 119 Standards, and more new Standards have been issued during this year (93) than any other year. Seventy-five per cent of the Standards approved are classified as of direct value to the war effort: 25 per cent War Standards developed under the war emergency procedure, and 50 per cent permanent Standards. The remaining 25 per cent issued during the year are Standards approved in preparation for postwar activities.

During the year seven Standards have been approved and put to use covering various types of insulators, insulating material, and resistors. Fourteen additional Standards on this subject are under way.

One Standard, a specification for applying shock tests to electrical instruments, provides standard methods for testing electrical indicating instruments under conditions intended to simulate combat field conditions. Such tests are needed by the armed services for delicate electrical indicating instruments used in tanks and planes to insure that they will remain in service and give accurate results under the very severe conditions of combat.

A large amount of work was reported to have been done during the year by the committee on photographic Standards. This has included the adoption of a whole range of standard sizes for roll film and spools to produce the interchangeability required by the Armed Forces. The work also included Standards of rating of photographic speed and speed number for use in connection with the emergency photographic exposure guide developed last year at the request of the armed forces. Recently the War Production Board asked that specifications be developed for the various types of photographic and cinematographic equipment to be used by the Armed Forces. A war committee is already at work on this project.

The war has in many ways given a great impetus to the standardization movement by increasing the appreciation of the importance of standards, it was reported. A few months ago when the scarcity of critical materials was at its height the War Production Board issued a statement crediting the establishment of Standards with having saved 60,000 tons of steel and 17,000 tons of copper. Australia is using the American Standards for radio, and Canada has adopted eight of them. Australia, Canada, and Great Britain have adopted the American War Standards for Quality Control.

United Engineering Trustees, Inc., Elects Officers; Issues Report

At the annual meeting of the United Engineering Trustees, Inc., held October 28, 1943, the following officers for the year 1943–44 were elected: *president*, F. Malcolm Farmer (F '13); *first vice-president*, Arthur S. Tuttle; *second vice-president*, Charles E. Stephens (M '22); *treasurer*, Arthur S. Tuttle (re-elected); *assistant treasurer*, W. D. B. Motter, Jr. (re-elected); and *secretary* and *general manager*, John H. R. Arms (re-elected).

Members of the board of trustees of UET for 1943–44 are:

Terms expiring October 1944

Charles E. Trout, ASCE
W. D. B. Motter, Jr., AIME
Kenneth H. Condit, ASME
Everett S. Lee, AIEE

Terms expiring October 1945

A. L. Queneau, AIME
F. Malcolm Farmer, AIEE

Terms expiring October 1946

J. P. H. Perry, ASCE
Henry A. Lardner, ASME

Terms expiring October 1947

Arthur S. Tuttle, ASCE
Albert Roberts, AIME
George L. Knight, ASME
Charles E. Stephens, AIEE

Members of the finance committee are:

Charles E. Stephens, *chairman*
Arthur S. Tuttle
Albert Roberts
Henry A. Lardne
George L. Knigh
F. Malcolm Farmer, ex offic

Members of the real estate committee are

Charles E. Trout, *chairman*
J. P. H. Perry
A. L. Queneau
Kenneth H. Cond
Everett S. Le
F. Malcolm Farmer, ex offic

Members of the executive committee are:

F. Malcolm Farmer, *chairman*
Charles E. Trout
Henry A. Lardne
Charles E. Stephen
Arthur S. Tuttle

United Engineering Trustees, Inc., wa organized in 1904 to manage property an funds held jointly by the four nationa Founder Societies: American Society c Civil Engineers, American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, an the American Institute of Electrical Engineers. The UET maintains two departments, the Engineering Societies Library an the Engineering Foundation, reports c which appear elsewhere in this issue. Th corporation (UET, Inc.) manages the Engineering Societies Building and all trus funds placed with the UET, Inc.

ANNUAL REPORT

The annual report of UET, Inc., for th year 1942–43 has been submitted to th AIEE and other participating societies b Albert Roberts, president. Essential substance of the report follows.

The second year of the war has require readjustments in many of the operations c the corporation. Rising wage and materia costs in the case of UET have not been offse by increased income. On the contrary, i has been reduced by decreased use of meeting halls. Changes in the budget for th coming year have been made on the basi of a six-month thorough study of the possibilities of means of increasing income an effecting economies in operation.

The Engineering Societies Building ha participated in the war effort by housing wa agencies and by supplying a center fo recruitment of engineer companies, and fo lectures and classes in ordnance and othe departments of the armed services. Th office space in the building has been full occupied for the entire year and, in one case two meeting halls have been arranged fo occupancy as office space "for the duration.

Operating expenses were sharply increase because of the higher wage rates for building service employees ordered by the War Labo Board and the higher costs of maintenanc materials. On the other hand, the incom of the corporation has been reduced becaus of a continued decline in hall rentals; reservations for classes had to be cancelled whe the students left the vicinity for war work c for the armed forces.

The net result of decreased income an increased costs was a deficit which woul have been $11,270.24 had not the Founde Societies assumed responsibility for th greater part of this amount.

Insurance inspectors report that th building is in excellent physical conditio No major repairs or alterations were mad during this past 37th year of use. In add tion to the usual insurance carried on th property and on the Engineering Societi Library—namely fire, supplemental cove age, and liability and compensation insu e—war-damage insurance was taken out n.

'he annual audit shows the finances of T to be in good condition. The cor- ation's portfolio is composed of trust ls amounting to $1,176,599.36, and a reciation and renewal fund which has n accumulated over many years and ch amounted to $474,544.11 at the end he year. The fund was increased during fiscal year by a total of $40,304.63, after ipt of the transfer from the building rations reserve of $20,000, as in years , interest and dividends amounting to ,655.70, and gains of $3,648.93 on re- estment of capital funds.

'he corporation acts as custodian for the ls of the John Fritz and Daniel Guggen- n Medal Boards, and other smaller funds, uding contributions from industry to plement the funds of The Engineering ndation for research projects directed by n. Also, it continues as treasurer for the gineer's Council for Professional Develop- it.

gineering Foundation Report ssued; Officers Elected

'he following officers for the year 1943– were elected at the recent annual meet- of The Engineering Foundation, joint arch agency of the Founder Societies: *rman*, A. L. Queneau (re-elected); *vice- rman*, Kenneth H. Condit; *director*, Edwin Colpitts; and *secretary*, John H. R. Arms. mbers of the executive committee, in ition to the chairman, vice-chairman, l secretary of the Foundation are: J. P. Perry, W. I. Slichter (F '12), and Charles Stephens (M '22).

Members of the Foundation board for 3–44 with the dates of expiration of their ns are:

tees elected by the board of trustees of UET, Inc.

neth H. Condit, ASME, 1947
rles E. Stephens, AIEE, 1947
. Queneau, AIME, 1945
. H. Perry, ASCE, 1944

fficio, president, UET, Inc.

Malcom Farmer

ibers nominated by Founder Societies

Malcolm Farmer, AIEE, 1947
D. Justin, ASCE, 1947
. Potter, ASME, 1947
. Colcord, AIME, 1946
M. T. Ryder, ASCE, 1946
rge D. Barron, AIME, 1944
vards R. Fish, ASME, 1944
I. Slichter, AIEE, 1944

ibers-at-large

H. Chambers, ASCE, 1947
. Kinzel, AIME, 1947
E. Buckley, AIEE, 1946

Members of the research procedure com- tee are:

neth H. Condit, *chairman*, ASME
M. T. Ryder, ASCE
E. Wessman, ASCE
M. Peirce, AIME
Trinks, ASME
A. Lewis, AIEE

Chairman Queneau was appointed to rep- ent the Foundation on the executive board he National Research Council.

American-Built Generators Travel to Iceland

Final adjustments are being made here on the first of two 38-ton generators under construction at the Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., which are destined for Iceland. This horizontal-type generator, which will supply power to cities as well as United States Army encampments, will add almost 3,000,000 watts to the island's electric output

The personnel of other committees as appointed or reappointed at this meeting is as follows:

Iron Alloys Committee

George B. Waterhouse, *chairman and director;* professor of metallurgy, Massachusetts Institute of Technology. Cambridge, Mass., AIME.

Lyman J. Briggs, director, National Bureau of Standards, represented by J. G. Thompson, senior metallurgist, National Bureau of Standards, Washington, D. C.

R. R. Sayers, director, United States Bureau of Mines, represented by R. S. Dean, assistant director, United States Bureau of Mines, Washington, D. C.

James T. Mackenzie, chief metallurgist, American Cast Iron Pipe Company, Birmingham, Ala., representing American Iron and Steel Institute.

John Johnston, director of research, United States Steel Corporation, Kearny, N. J., representing American Iron and Steel Institute.

James H. Critchett, vice-president, Union Carbide and Carbon Research Laboratories, Inc., New York, N. Y., representing American Electrochemical Society.

Bradley Stoughton, professor emeritus, Lehigh University, Bethlehem, Pa., representing American Society for Metals.

Jerome Strauss, vice-president, Vanadium Corporation of America, New York, N. Y., representing American Society for Testing Materials.

T. H. Wickenden, assistant manager, development and research, the International Nickel Company, Inc., New York, N. Y., representing Society of Automotive Engi-[illegible]

Wilfred Sykes, president, Inland Steel Company, Chicago, Ill., member-at-large.

Frank T. Sisco, *consultant*, assistant secretary, AIME, New York, N. Y.

Welding Research Council

C. A. Adams, *chairman*, E. G. Budd Manufacturing Company, Philadelphia, Pa.

A. S. Albright, acting chief of research, Detroit Edison Company, Detroit, Mich.

David Arnott, vice-president, American Bureau of Shipping, New York, N. Y.

H. C. Boardman, *vice-chairman*, director of research, Chicago Bridge and Iron Company, Chicago, Ill.

Everett Chapman, P. O. Box 387—Coatesville, Pa.

O. U. Cook, assistant manager, department of metallurgy, inspection and research, Tennessee Coal, Iron. and Railroad Company, Birmingham, Ala.

J. H. Critchett, vice-president, Union Carbide and Carbon Research Laboratories, New York, N. Y.

J. J. Crowe, assistant to vice-president and operating manager, Air Reduction Sales Company, New York, N. Y.

C. L. Eksergian, chief engineer, Budd Wheel Company, Detroit, Mich.

A. J. Ely, mechanical engineer, Standard Oil Development, Elizabeth, N. J.

F. H. Frankland, director of engineering, American Institute of Steel Construction, New York, N. Y.

T. S. Fuller, works laboratory, General Electric Company, Schenectady, N. Y.

Isaac Harter, vice-president, Babcock and Wilcox Company, Barberton, Ohio.

D. S. Jacobus, advisory engineer, 93 Harrison Avenue, Montclair, N. J.

G. F. Jenks, 232 Avondale Avenue, Los Angeles, Calif.

Carl M. Loeb, Jr., vice-president, Climax Molybdenum Company, New York, N. Y.

Arthur E. Pew, vice-president, Sun Oil Company, Philadelphia, Pa.

A. C. Weigel, vice-president, Combustion Engineering Company, New York, N. Y.

Clyde Williams, national defense research committee, Battelle Memorial Institute, Columbus, Ohio.

A. R. Wilson, engineer of bridges, Pennsylvania Railroad, Philadelphia, Pa.

R. E. Zimmerman, vice-president, United States Steel Corporation of Delaware, Pittsburgh, Pa.

W. Spraragen, *executive secretary*, Welding Research Council, 29 West 39th Street, New York, N. Y.

ANNUAL REPORT

The salient points of the annual report of the Engineering Foundation, as submitted by chairman A. L. Queneau to the AIEE and other Founder Societies at the meeting on October 21, 1943, follows.

The Engineering Foundation, which was established in 1914, completed its 29th fiscal year on September 30, 1943. The book value of the capital funds of the Foundation on that date was $959,000, as compared with $952,000 on September 30, 1942. The income for the fiscal year 1942–43 was $35,160.38, as compared with $34,274.09 for the previous year. Disbursements amounted to $31,790.20, as compared with $31,430.36 for the year 1941–42. The balance on September 30, 1943, was $28,292.87, as compared with $24,922.69 on September 30, 1942.

It has been the policy of the Foundation for many years to contribute to a considerable number of projects in the diverse fields of engineering. In general, attempt is made to select projects of a fundamental type which normally would not be undertaken by industrial research organizations. In certain other cases the Foundation serves as a catalyzing agent, so to speak, for projects which are largely supported by contributions from industry. This policy of the Foundation has been continued for the year 1942–43, but the projects have been scrutinized with regard to their bearing on the war, and have been encouraged only insofar as they appeared to contribute to the war effort.

Because of the Government's willingness to support research projects demonstrated as important to the war effort, and because of the withdrawal of research personnel to more direct war activities, the immediate demands upon the Foundation's income for the support of research projects helpful to the national cause seem likely to decrease. However, in the years following the war, it is certain that engineering research in many fields should be encouraged and expanded. Consequently, in those years the Foundation could doubtless employ a much larger income than almost surely will be available from its present capital funds.

During the year, work on 14 projects has continued. For the ensuing year, grants were recommended for continuation of work on six projects and the initiation of one new project.

Summaries of the research projects which were sponsored by the Foundation and with which AIEE has been associated directly follow:

Insulation Oils and Cable Saturants. (Foundation grant, $1,000. Chairman, Herman Halperin, assistant equipment and research engineer, Commonwealth Edison Company, Chicago, Ill.)

This project, which has been supported in part by the Foundation for a number o years, concerns the stability of insulating oils in power cables and other electrical apparatus. An important feature of the work during the fiscal year 1942–43 were the studies on factors influencing the electrical stability of mineral oils under limited-oxidation conditions. These limited oxidation conditions are particularly important in the practical application of oilpaper insulation. Whereas a complete solution of the problem has not been attained, several factors influencing this stability have been determined, and complete systems of test and equipment have been developed.

The effect of oxidation inhibitors and other additives on the electrical stability of mineral oils under limited oxidation has been studied, also, as has the effect of percentage of aromatics. This latter has been studied by blending cuts of an oil having different degrees of aromaticity. The effect of variable temperature has been observed in limited-oxidation studies. Tests have been made over a temperature range from 85 to 145 degrees centigrade. These tests were made with both oil and oilpaper in contact with copper. Furthermore, these variable-temperature tests have been made with different amounts of available oxygen.

Studies were made, also, on the effect of different degrees of refining on limited oxidation. Oils for this purpose were supplied by the Sun Oil Company, and consisted of samples having four different degrees of refining treatment, one of the intermediate ones being the normal or conventional amount. Service-aged and specially processed oils supplied by contributing companies were subjected to various tests.

During the past year, two papers were prepared in connection with this project. The first of these was "Mineral Insulating Oils—Effect of Additives on Electrical and Chemical Stability," by A. G. Assaf and J. C. Balsbaugh (*Industrial and Engineering Chemistry*, volume 35, August 1943, pp. 909–16). "Electrical Stability of Electrical Insulating Oils Under Limited Oxidation," by J. C. Balsbaugh and A. G. Assaf, was presented before the winter technical meeting of the AIEE, New York, N. Y., January 1943, and became available to the industry the first of the present fiscal year.

The advisory committee for this project held two meetings during the past year, on September 28, 1942, and on January 25, 1943. At the second meeting the committee members agreed that the research, in spite of its value and promises, should not be continued beyond August 31, 1943, unless it could be shown that the activities had become directly concerned with the war effort. As no such special problems developed, the committee recommended suspension of the project as of August 31, 1943, with the consideration that it might be desirable to resume it after the war.

Welding Research Council. (Foundation grant $4,000. Chairman, Comfort A. Adams, E. G. Budd Manufacturing Company, Philadelphia, Pa.)

About January 1, the Welding Research Committee was completely reorganized and renamed the Welding Research Council. This reorganization was undertaken to bring about a simplification of structure and to enable the Welding Research Council to carry on its activities more closely with the war effort. Some committees were discontinued for the duration of the war and the work formulated under the following project committees. Duplication of effort and red tape, in the opinion of the Council, have been eliminated almost completely.

Aircraft welding research committee
Fatigue-testing (structural) committee
High-alloy steels
Light alloys
Literature committee
Nickel alloys
Resistance welding
Structural steel committee
University research committee
Weldability
Weld-stress committee

Under cognizance of these committees, studies and investigations of broad scope relating to many phases of welding have been continued. Co-operation with the aircraft industry has been maintained, in part a least, through the National Advisory Committee for Aeronautics. Various research projects started under the university research committee have been taken over and largely expanded by the National Defense Research Committee.

As to publications, during the year 620 (9 by 12) printed pages were published covering approximately 79 reports on almost every phase of welding.

LIBRARY • • • • • •

OPERATED jointly by the AIEE and the othe Founder Societies, the Engineering Societies Library, 29 West 39th Street, New York 18, N. Y., offers a wide variety of services to members all ove the world. Information about these services may be obtained on inquiry to the director.

Board and Officers of Library Elected; Annual Report Issued

At the recent annual meeting of the Engineering Societies Library board, W. A. Del Mar (F '20) was reappointed chairman for 1943–44 and W. D. B. Motter, Jr., was appointed vice-chairman. Harrison W. Craver was reappointed director of the Library and secretary of the board.

Members of the library board are a follows:

Terms expiring October 1944

J. K. Finch, ASCE
James W. Laist, AIME
A. R. Mumford, ASME
W. A. Del Mar, AIEE

Terms expiring October 1945

Edward P. Hamilton, ASCE
W. A. Mudge, AIME
John Blizard, ASME
W. I. Slichter, AIEE

Terms expiring October 1946

Charles E. Trout, ASCE
Thomas T. Read, AIME

Terms expiring October 1947

E. F. Church, Jr., ASME
George L. Knight, AIEE

Members at Large

George F. Felker
Sydney H. Ball
Robert H. Barclay

Members of the executive committee fo 1943–44 are:

E. F. Church, Jr.
E. P. Hamilton
G. L. Knigh
T. T. Rea

ANNUAL REPORT

The annual report of the Engineerin Societies Library for the year 1942–43 ha been submitted by Harrison W. Craver, di rector, to the AIEE and other Founde Societies. Essential substance of the repor follows.

The past year in the library has been a con stant scramble to keep up with the flood c inquiries from members engaged in war wor and from departments of the Government, a of whom wanted definite information upo details of manufacturing processes, upo foreign factories, docks, public works, an other matters of military significance. A this information was wanted immediatel Much of it was too novel to have appeare yet in print to any great extent.

Operation of Library

aintenance revenue	$49,393.62	
aintenance expenditures	42,642.25	
Credit balance for year 1942–43	6,751.37	
Credit balance from previous years	11,382.79	
Credit balance September 30, 1943		$18,134.16
rvice bureau revenue	$14,415.24	
rvice bureau expenditures	11,162.64	
Credit balance for year 1942–43	3,252.60	
Credit balance from previous years	4,974.88	
Credit balance September 30, 1943		8,227.48
tal net operating credit balance cumulated to September 30, 1943		$26,361.64

The year's experience has proved the undness of the book collection. The small llection of Japanese books and periodicals the library has proved to be the most ex- nsive in the country, and the collection of erman works has seldom failed to produce e book desired. The library has lent a umber of these to publishers who were uthorized by the Alien Property Custodian reproduce them. The large resources of e library in older works and in files of reign magazines have proved invaluable providing material.

As a result, the collection has been used tensively by the Army and the Navy. ertain of their researchers arrive as soon as e library opens in the morning and work roughout the day. Others come regularly om Washington, D. C., and other centers search the files. The war has created a owing appreciation of the value of refer- nce libraries as storehouses of knowledge. he necessity for building them up in ad- ance of need has become apparent as never fore.

Service to the Government has not ended ith provision of books. One assistant was nt to the Army Corps of Engineers for ven months, during which time she or- nized its cataloguing and indexing service oon a satisfactory basis. Another was re- ased for several days a month to act as nsultant to the Signal Corps in building a reference library in Washington, D. C. addition, the staff as a whole constantly as been giving freely of its experience and owledge as occasion arose.

Whereas the library was used by more eople than in the previous year, the increase as the result of greater use by mail by non- sident members rather than by a greater umber of visitors to the library itself. The umber of visitors was 22,260, as compared ith 23,734 in 1941–42, and 13,579 others ave made use of it in other ways, as com- ared with 10,648 for that year. Total umber of users of the library was 35,839 r 1942–43, and 34,382 for the preceding ear.

The greatest increase in service was in lls for photostats. This year 3,487 orders r photostats and microfilms were received, increase of 15 per cent. The number of ints made was 38,702, an increase of 23 r cent.

Telephone inquiries numbered 6,689, an crease of 10 per cent. The number of bor- wers was 1,055, an increase of 62 per cent, whom 1,393 books were lent. Letters ere written to 2,232 members, answering uestions that did not call for sustained arching. This represented an increase of 30 per cent over the preceding year. In addition, 86 searches and 30 translations were prepared.

The fact that the 13,579 persons who used the library without visiting it constituted 38 per cent of the users is gratifying, and shows the extent to which the membership at large is using the collection.

On December 26, 1942, W. S. Barstow (F '12), for many years a member of this board died. Mr. Barstow's interest in the library was deep and had been manifested on many occasions by generous gifts, among them being one of several thousand dollars to repair and restore the bindings of the rare book collection. He also left a bequest of $10,000 to the library. His wise counsel and pleasant personality will be sadly missed by the board and the director.

The library suffered another severe loss, on September 13, 1943, through the death of Harrison A. von Urff. For seven years Mr. von Urff had been in charge of bibliographic work. During that time hundreds of members had learned to know his great skill in locating printed information, and to admire his modesty and quiet helpfulness. His unusual talent for this work will be hard to replace.

The tendency toward reduction in book output, which was noted in the preceding report, has continued. The technical publishers have been kept busy by the demands of the Army and Navy for enormous numbers of elementary textbooks for training the forces. In addition, most engineers who would normally be writing are too busy to do so. The scarcity of paper and binding materials, plus the impossibility of getting European books, has resulted in fewer books being added to the library. Whereas 10,286 books and pamphlets were received—almost as many as in the preceding year—only 2,010 of these were adjudged worthy of permanent preservation, as compared with 5,523 in that year. This reduction reflects the effect of the war upon technical publication.

During the year the staff reviewed 420 books for the periodicals of the Founder Societies.

At the end of the year the library contained 156,780 volumes, 7,872 maps, and 4,565 searches, a total of 169,216 items.

As in former years, the library has been the constant recipient of gifts from members and friends. To mention all of these in detail is impracticable, but a few of unusual extent may be noted.

The estate of John R. Freeman presented the major portion of Mr. Freeman's professional library, consisting of thousands of reports and books collected during a long, busy life and covering the varied branches of civil engineering in which he had been eminent. Other important gifts included a large collection of periodicals from Pope Yeatman, another from Mrs. C. Minot Weld, and a third from Charles N. Green. George H. Gibson presented a useful collection of American and German periodicals. Ernest P. Goodrich also added materially to our resources, as did Spencer, White and Prentis; T. G. Townsend; and Joseph Meltzer. The McGraw-Hill Book Company, Inc., presented many hundreds of books which had come to its editorial offices for review purposes.

To these and other donors our hearty thanks are given.

The budget established for general operation was $50,000, of which the following amounts were provided by the Founder Societies, on a membership basis:

American Society of Civil Engineers	$10,132.10
American Institute of Mining and Metallurgical Engineers	8,227.10
American Society of Mechanical Engineers	9,471.20
American Institute of Electrical Engineers	10,501.70
	$38,332.10

Expenditures from this budget amounted to $42,642.25 of which $6,442.75 was spent for books, periodicals and other equipment of permanent value. Service Bureau receipts for special service were $14,415.24 and its expenses were $11,162.64.

INDUSTRY

Sylvania Increases Electronics Output With New Gas Plant

A new electrolytic plant at Williamsport, Pa., costing in excess of $150,000 and equipped with 108 electrolytic cells, high-powered compressor machines, low-pressure and high-pressure storage tanks, and a water distillery, which will furnish hydrogen and oxygen for tube makers in the Williamsport and Towanda, Pa., factories, has just been completed by Sylvania Electric Products Inc.

"Consuming a gallon of water per cell per hour, our generator will produce 2,000 cubic feet of hydrogen and half as much oxygen per hour," said Bruce Goldsmith, manager of the plant. The storage tanks contain water which is broken down by a direct current of 1,200 amperes at 150 volts. Each cell has two compartments, one containing the electrode that liberates hydrogen, the other containing the oxygen electrode. The gas rises and is carried away by a system of pipes overhead, goes to low-pressure tanks, and later is compressed to 300 to 2,500 pounds pressure.

Lightning Frequency Registered by Plastic Device

Perfection of a counting device which will point out vulnerable spots requiring protective arresters by recording data on the frequency of lightning strokes along transmission systems, has been announced by

Doctor Leo Finzi (A '40) research engineer, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

About the dimensions of a playing card, the counter consists of two strips of metal foil enclosed between two pieces of transparent plastic material. One foil strip is edged with teeth which are a few thousandths of an inch from the straight edge of the second strip. When lightning strikes a power line, a small part of the current is sidetracked into the saw-toothed strip and must jump to the straight-edged strip to reach the ground. Taking the easiest path—the tooth whose tip is nearest the straight-edged strip—the current closes this gap and makes a tiny spark which scorches a black spot on the plastic and burns away the tip of the tooth, so that the next discharge must follow another path. Since no two of the gaps between the strips are exactly the same, one path is always easiest for the current, and the counter never misses recording a stroke of lightning. As soon as the spark occurs, the voltage in the strip drops and another spark will not occur until lightning strikes again which obviates the possibility of one lightning stroke's being recorded more than once. The device easily can be fastened near the bottom of a power-line tower so the blackened dots on it can be counted in a few seconds.

OTHER SOCIETIES •

ICI Program Promotes Advances in Heating and Cooling

Organization of the Indoor Climate Institute, an industry-wide co-operative educational program for the improvement of heating, cooling, and air conditioning, has been announced by Paul B. Zimmerman, president. A board of directors, and advisory council, and executive officers have been elected, and headquarters have been established at Detroit, Mich.

Sponsored by leading manufacturers of heating, cooling, and equipment industries, suppliers of controls and accessories, and producers of major heat conservation materials, the Institute will serve as a clearinghouse of information. The technical committees of the ICI will make a study of the codes, standards, and practices as established by the various industry trade associations and authorities for the benefit of the public, and will co-operate with manufacturers and trade associations in developing potential markets.

Future Meetings of Other Societies

American Institute of Mining and Metallurgical Engineers. Annual meeting, February 20–24, 1944, New York, N. Y.

American Society of Civil Engineers. January 19–21, 1944, New York, N. Y.

American Society of Heating and Ventilating Engineers. 50th annual meeting, January 31–February 2, 1944, New York, N. Y.

American Society of Mechanical Engineers. Spring meeting, April 3–5, 1944, Birmingham, Ala. Semi-annual meeting, June 19–20, 1944, Pittsburgh, Pa.

Engineering Institute of Canada. Annual meeting, February 1–11, 1944, Quebec, Que.

National Electrical Manufacturers' Association. April 23–7, 1944, Chicago, Ill.

National Fire Protection Association. May 8–11, 1944, Philadelphia, Pa.

New Association Organized by Corrosion Engineers

A new organization to be known as the National Association of Corrosion Engineers is being formed by the Mid-Continent Cathodic Protection Association, and all persons engaged in the work of corrosion control or mitigation on underground metallic structures are invited to apply for membership. Inquiries should be directed to O. C. Mudd, acting secretary-treasurer, care of Shell Pipe Line Corporation, Box 2648, Houston 1, Tex., or to R. A. Brannon, acting president, care of Humble Pipe Line Company, Drawer 2220, Houston 1, Tex. The new group plans to hold an annual meeting April 10, 11, and 12, 1944, at the Rice Hotel, Houston, to which all members or applicants for membership are invited.

The Mid-Continent Cathodic Protection Association, formed in 1938 for the purpose of exchanging information regarding developments in the field of mitigation or prevention, by electrical means, of corrosion to pipe lines and other metallic structures, has been meeting and carrying on its work as the cathodic section of the Petroleum Industry Electrical Association. The group is also interested in the promotion of co-operative action between companies or organizations and the development of standard procedures and methods for use in connection with corrosion control.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Voltage Drop Through the Armature Circuit

To the Editor:

A common method of determining the internal resistance of a battery is to load the battery through two different values of external resistance. The internal resistance of the battery is then calculated from the equation:

$$R=\frac{(E_1-E_2)R_1R_2}{E_2R_1-E_1R_2} \text{ or } \frac{R_1I_1-R_2I_2}{I_2-I_1}$$

The determination of the internal resistance of the armature circuit of a d-c motor or generator under operating conditions offers an analogous problem and suggests the application of a similar solution. The voltage relations in a motor are expressed by

$$V=E+RI=K\phi S+RI$$

where

V is the applied terminal voltage.

E is the counterelectromotive force of the motor and equals $K\phi S$.

K is a constant depending upon the construction of the machine.

ϕ is the flux cut by the armature conductors and may be made constant if the field current and armature-ampere turns are maintained constant.

S is the speed of the armature.

R is the internal resistance of the armature, and includes the copper resistance of the winding and the contact drop between the brushes and the commutator.

I is the armature current.

The copper resistance of the armature may be measured satisfactorily at standstill, but it is questionable as to whether the contact drop at standstill is the same as under running conditions.

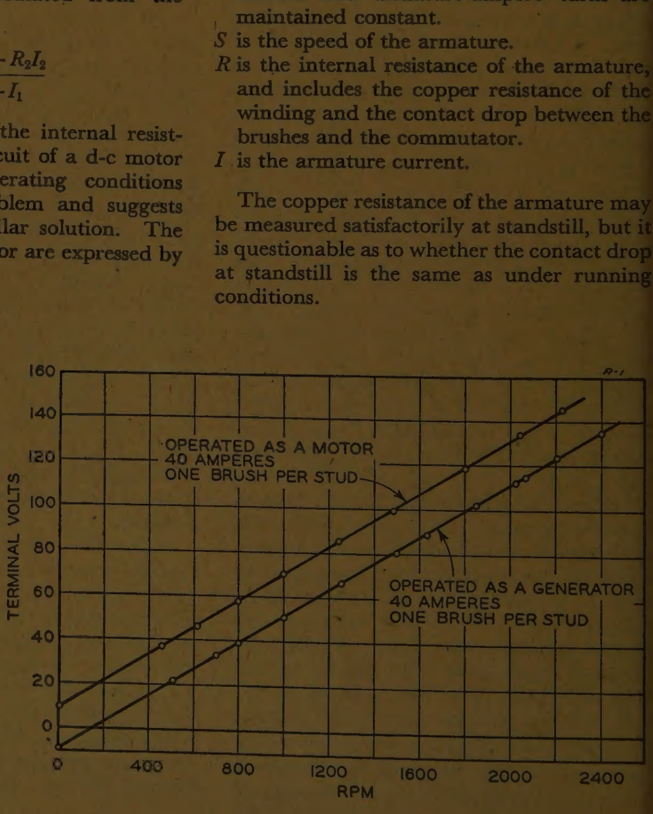


Figure 1

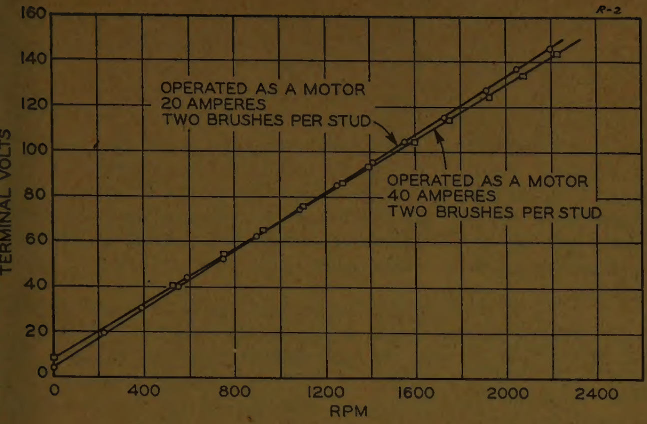


Figure 2

If the motor is run with a known resistance $_2$ in series with the armature circuit and at he same time the load is adjusted to main-ain a constant armature current a second peed is observed.

hen

$$=kS+RI$$

nd

$$=kS_2+(R_2+R)I$$

vhere

$$=K\phi$$

ince ϕ is constant

Ience

$$=\frac{V}{I}-R_2\frac{S}{S-S_2}$$

Since the solution involves using the differ-nce of two speeds, it does not lend itself to a igh degree of accuracy. In place of using n auxiliary external resistance, equally good esults can be obtained simply by applying nore than one voltage at the terminals of the rushes while maintaining the armature urrent and field excitation constant.

$$=kS+RI$$

It is noticed that this relation is a straight ne, if the value of R, that is the copper and ontact drop, remains constant with change f speed. If projected to the ordinate of zero eed, it gives the armature-circuit voltage rop.

An experimental run, using a five-kilowatt enerator gave the results shown in Figures 1 nd 2. The curves show that within the mits of experimental error the drop through e armature circuit while running is the ame as the drop at standstill provided the andstill drop is measured immediately after e machine is shut down and while the rushes are still hot.

It is conceivable that the contact drop ight vary proportional with the speed and ius make the above equation a straight line. o test this, the machine was run as a genera-r, resulting in another straight line which is ibstantially parallel with the motor line, idicating that the contact drop is constant.

A run made with half the brushes removed, oubling the current density, brings out the icrease in contact drop with increase in irrent density.

For any particular value of field current e slope of the straight line curve gives the alue of k in the equation:

$$=kS+RI$$

The plot of the data obtained by runs made with a constant field current and three values of armature current, 20, 30, and 40 amperes, brings out the fact that the field flux is dependent upon both the field ampere turns and the armature ampere turns, as each value of armature current gives its corresponding value of k, run as a motor, the larger values of armature current give smaller values of k, that is, smaller values of ϕ, and greater speed of the motor for any given value of counterelectromotive force.

H. S. RUSH (M '30)

(Assistant dean, school of engineering and professor of electrical engineering, North Dakota Agricultural College, Fargo)

NEW BOOKS • • •

The following new books are among those recently received from the publishers. Books designated ESL are available at the Engineering Societies Library; these and thousands of other technical books may be borrowed from the library by mail by AIEE members. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books. All inquiries relating to the purchase of any book reviewed in the columns should be addressed to the publisher of the book in question.

Descriptive Geometry for Engineers. By H. C. Bradley and E. H. Uhler. Second edition. International Textbook Company, Scranton, Pa., 1943. 266 pages, illustrated, 9 by 6 inches, cloth, $2.50.

Problems in Descriptive Geometry for Engineers. By E. H. Uhler. International Textbook Company, Scranton, Pa., 1943, no pagination, illustrated, 9 by 12 inches, paper, $1.75. (ESL.)

Part I of this text deals with fundamental principles, covering projections, constructions, surfaces, intersections, methods of revolution, and the method of traces. Part II describes the application of these principles to engineering problems: civil, mechanical, chemical, mining, and structural geology.

The text is supplemented by a separate book of plates containing problems to be solved by both graphical and mathematical methods. Plates are numbered to refer to chapter and article of the explanatory text.

Engineering Encyclopedia. Edited by F. D. Jones. 2 volumes. Second edition. Industrial Press, New York, N. Y.; Machinery Publishing Company, Ltd., Brighton, England, 1943. 1,431 pages, illustrated, 9$^1/_2$ by 6 inches, fabrikoid, $8. (ESL.)

This two-volume reference work supplies such practical and useful engineering information as the various important mechanical laws, rules, and principles; physical properties and compositions of a large variety of materials used in engineering practice; the characteristic features and functions of different types of machine tools and other equipment; and so forth. The 4,500 topics included are alphabetically arranged and cross-indexed for convenient reference, and have been selected for their usefulness in the mechanical industries.

How to Maintain Electrical Equipment. General Electric Company, Schenectady, N. Y., 1943. 372 pages, illustrations, 8$^1/_4$ by 10$^1/_2$ inches, $1.75.

To help industrial plants secure maximum performance and length of service from electrical equipment, the General Electric Company has prepared this volume of general suggestions for maintenance engineers. Among others, sections are devoted to battery trucks, cable and wire, Diesel-electric locomotives, electric furnaces, fuse cutouts, industrial control, lighting, motors and generators, rectifiers, switchgear, transformers, and welders. Each section contains a preventive-maintenance chart and a trouble-shooting chart. Numerous diagrams and pictures supplement the text.

Mathematischen Hilfsmittel des Physikers (Mathematical Tools for the Physicist). By E. Madelung, K. Boehle, and S. Flügge. Third edition; published and distributed in the public interest by authority of the Alien Property Custodian under license A-146; American edition, Dover Publications, New York, N. Y., 1943. 384 pages, illustrated, 9$^1/_2$ by 6 inches, cloth, $3.50. (ESL.)

The purpose of this book is to provide for physicists a concise statement of those parts of mathematics that are of direct use to them, and which otherwise could be obtained only by consulting a large variety of textbooks. The first section is devoted to mathematics; the second to physics. This American edition is a photographic copy of the German edition of 1935, offered at about one third the former price.

Water Power Engineering. By H. K. Barrows. Third edition. McGraw-Hill Book Company, New York, N. Y., and London, England, 1943. 791 pages, illustrated, 9 by 6 inches, cloth, $6. (ESL.)

The whole field of water-power development for hydrolectric purposes is covered in this standard textbook. Beginning with hydrology and the study of stream-flow data it continues through the construction and operation of dams, canals, and penstocks to a discussion of the powerhouse and its equipment. There are chapters on turbine regulation and on transmission lines. The cost and value of water power are discussed, and typical installations are described briefly.

Diesel Engineering Handbook. 1943 de luxe edition. Originally edited by L. H. Morrison, revised by C. F. Foell. Diesel Publications, New York, N. Y. 966 pages, illustrated, 9$^1/_2$ by 6 inches, cloth, $7. in United States; $8. in foreign countries. (ESL.)

Practical, up-to-date information, valuable both to the owner and operator, is provided upon the operation and maintenance of Diesel engines. The treatment is exhaustive, and the book is illustrated profusely from actual practice. Two chapters of engineering fundamentals are devoted to brief description of useful general engineering terms and equipment.

Graphical Construction for Vacuum Tube Circuits. By A. Preisman. McGraw-Hill Book Company, New York, N. Y., and London, England, 1943. 237 pages, illustrated, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, cloth, $2.75. (ESL.)

This book is concerned mainly with the graphical methods by which solutions to problems on nonlinear circuits, particularly those involving vacuum tubes are obtained. Special attention is paid to those problems which are not amenable to the analytical method, but others are included which utilize a combination of the two methods. Much of the material is a revision of magazine articles previously published by the author.

Fundamentals of Optical Engineering. By D. H. Jacobs. McGraw-Hill Book Company, New York, N. Y., and London, England, 1943. 487 pages, illustrated, $8^{1}/_{2}$ by 5 inches, cloth, $5. (ESL.)

By providing an introductory text which gives attention both to optical and mechanical design, this book fills a gap in the literature on optical instruments. The fundamentals of optics are set forth first, and followed by descriptions of such representative instruments as telescopes, periscopes, gun sights, and range finders. Following this, the mechanical, electrical, and optical design of instruments is discussed.

Encyclopedia of Substitutes and Synthetics. Edited by M. D. Schoengold. Philosophical Library, New York, N. Y., 1943. 382 pages, tables, $9^{1}/_{2}$ by 6 inches, cloth, $10. (ESL.)

This encyclopedia covers products that have been developed recently in order to replace critical materials that have become difficult or impossible to obtain. The properties and uses of these replacement materials are given; the materials needing to be conserved are listed with their practical substitutes; and a separate index of trade names is provided. All branches of industry, manufacture, and pharmaceutics are represented.

Electroplating. By S. Field and A. D. Weill. Fourth edition revised and enlarged. Sir Isaac Pitman and Sons, London, England; Pitman Publishing Corporation, New York, N. Y., 1943. 437 pages, illustrated, $7^{1}/_{2}$ by 5 inches, cloth, $5; 15s. (ESL.)

The major part of this text is devoted to description of the practical processes by which metals are deposited on a surface. Fundamental principles are discussed briefly; the electroplating plant is described; mechanical and chemical cleaning of metals is covered; and chapters are included on the testing of electrodeposits and on metal coloring.

Fundamentals of Engineering Drawing. By W. J. Luzadder. Prentice-Hall, Inc., New York, N. Y., 1943. 568 pages, illustrations, etc., $9^{1}/_{2}$ by 6 inches, cloth, $4. (ESL.)

The early chapters of this comprehensive work present simple instructions about necessary equipment and its use, and deal briefly with engineering geometry and the fundamentals of drawing technique. In the later chapters, detail work and the making of drawings for various engineering operations and other special purposes are described. A chapter on engineering graphs, charts, and diagrams is included.

Cellulose and Cellulose Derivatives. (High Polymers, volume 5.) Edited by E. Ott. Interscience Publishers, New York, N. Y., 1943. 1176 pages, illustrated, $9^{1}/_{2}$ by 6 inches, cloth, $15. (ESL.)

Thirty-six well-known workers have contributed to this monograph, which is intended to present "the most important modern scientific and technical information concerning cellulose and its derivatives and to have this information in such form that it becomes a thorough introduction for work on any cellulose problem by any person having reasonably wide general technical training."

Principles of Physical Metallurgy. By F. L. Coonan. Harper and Brothers, New York, N. Y., and London, England, 1943. 238 pages, illustrated, $9^{1}/_{2}$ by 6 inches, cloth, $3.25. (ESL.)

The fundamentals necessary for a general appreciation of the properties of metals and alloys are presented in this brief elementary text intended for students who require a knowledge of the nature and characteristics of the metals and alloys of commercial importance. The first section presents physical principles. The succeeding two sections deal respectively, with nonferrous alloys and alloys of iron and carbon.

Heat and Thermodynamics. By M. W. Zemansky. Second edition. McGraw-Hill Book Company, New York, N. Y., and London, England, 1943. 390 pages, illustrated, 9 by 6 inches, cloth, $4. (ESL.)

This intermediate textbook for students of physics, chemistry, and engineering, discusses in the first half the fundamental ideas of heat, ideal gases, reversibility, entropy, and so forth. The remaining chapters deal with physical, chemical, and engineering applications in sufficient detail to show how the general principles are applied to specific cases.

Mineral Resources of Africa. (African Handbooks: 2.) By A. W. Postel. University of Pennsylvania Press, Philadelphia, 1943. 105 pages, illustrated, $8^{1}/_{2}$ by $5^{1}/_{2}$ inches, paper, $1.50. (ESL.)

The available data on the mineral resources of Africa and their development; current production, reserves, and so forth, are summarized concisely in this pamphlet. The annual world production and the annual production of the chief producer of each mineral are given for comparison. The work affords a convenient survey of Africa's position in the mineral industry.

Elements of Electrical Circuits and Machinery. By G. C. Blalock. McGraw-Hill Book Company, Inc., New York, N. Y., and
London, England, 1943. 347 pages, illu
trations, etc., 8 by $5^{1}/_{2}$ inches, cloth, $
(ESL.)

This textbook is intended for brief cours
in circuit theory and the practical applic
tions of electrical equipment and is adapte
for use in technical high schools and trac
schools. Mathematics is used sparingly an
all references to calculus and differenti
equations are omitted. A list of laborato
experiments is included.

**Experiments in Electronics and Commun
cation Engineering.** By E. H. Schulz an
L. T. Anderson. Harper and Brothers, Ne
York, N. Y., and London, England, 194
381 pages, illustrations, etc., $9^{1}/_{2}$ by 6 inche
cloth, $3. (ESL.)

This laboratory guide has been prepare
for use in training men for the Signal Cor
of the United States Army. It is intended t
serve courses at college level in electronic
communication networks, radio, and ultr
high-frequency phenomena. Over 100 e
periments are given, with discussions o
principles and directions.

Geology of Kentucky. By A. C. McFarla
University of Kentucky, Lexington, 194
531 pages, illustrated, $9^{1}/_{2}$ by 6 inche
cloth, $4.50. (ESL.)

This work is a revision of Arthur M
Miller's "Geology of Kentucky," long out o
print. The literature on the stratigraph
regional geology, and mineral resources o
the state is summarized thoroughly. A
extensive bibliography is included.

PAMPHLETS ● ● ● ●

**The following recently issued pamphlets may b
of interest to readers of "Electrical Engineering.
All inquiries should be addressed to the issuer**

Electronics in Industry. RCA Victo
Division of the Radio Corporation o
America, Camden, N. J., 44 pages, n
charge.

Ignitron Mercury-Arc Rectifiers. Genera
Electric Company, Schenectady, N. Y.
36 pages, no charge.

Facts About Synthetic Rubber. New Yor
Belting and Packing Company, 1 Marke
Street, Passaic, N. J., 32 pages, no charge.

**Packaging, Marking, and Loading Meth
ods for Steel Products for Overseas Ship
ments.** American Iron and Steel Institute
350 Fifth Avenue, New York, N. Y., 21
pages, $2.50.

**Postwar Employment and the Settlemen
of Terminated War Contracts.** The Com
mittee for Economic Development, Roo
3311, Department of Commerce Building
Washington, D. C., 15 pages.

Your Business After the War. Researc
Institute of America, 292 Madison Avenue
New York 17, N. Y., 61 pages, $2.

**Membership List and Trade Directory
Radio Manufacturers Association, 1317
Street, N. W., Washington 4, D. C., 4
pages.

**Accident Rates in the Public Utility Indus
tries, 1942.** National Safety Council, Inc
20 North Wacker Drive, Chicago 6, Ill
24 pages, 20 cents.